



Lincoln County Class IV Asbestos Landfill Operations Plan

April 2003

Prepared for:



**U.S. Department of Transportation
Research and Special Programs Administration**

**John A. Volpe National Transportation Systems Center
Environmental Engineering Division, DTS-33
55 Broadway, Kendall Square
Cambridge, Massachusetts 02142**

Prepared by:

CDM.

One Cambridge Place
50 Hampshire Street
Cambridge, Massachusetts 02139

Lincoln County Class IV Asbestos Landfill Operations Plan

April 2003

Prepared by:

CDM.

One Cambridge Place
50 Hampshire Street
Cambridge, Massachusetts 02139

Approved by:

Ron Anderson
Lincoln County Sanitarian

Date

Contents

Section 1 Introduction

Section 2 Landfill Construction

Section 3 Landfill Operations

3.1	Waste Disposal	3-1
3.2	Dust and Airborne Particulate Control.....	3-3
3.3	Stormwater and Erosion Control.....	3-4
3.4	Decontamination.....	3-5
3.5	Health and Safety	3-7
3.6	Site Security	3-8
3.7	Waste Screening	3-8
3.8	Record Keeping.....	3-9
3.9	Methane Gas Generation	3-11

Section 4 Closure Plan

4.1	Cover Design	4-1
4.2	Post Closure	4-2

Section 5 Sampling and Analysis Plan

5.1	Air Monitoring	5-1
5.1.1	Meteorology.....	5-1
5.1.2	Ambient Sampling Stations.....	5-1
5.1.3	Personal Breathing Zone Air Sampling	5-2
5.1.4	Air Sample Collection and Analysis	5-3
5.1.5	Quality Control Air Samples	5-4
5.1.6	Sample Identification.....	5-4
5.1.7	Sample Documentation.....	5-4
5.1.8	Sample Custody, Packaging, and Shipping	5-5
5.1.9	Equipment Decontamination	5-5
5.2	Groundwater Monitoring	5-6
5.2.1	Field Investigation	5-6
5.2.2	Groundwater Sampling	5-6
5.2.3	Sample Analysis.....	5-8
5.2.4	Quality Assurance/Quality Control	5-9

Section 6 Construction Quality Assurance/Construction Quality Control Plan

6.1	Construction Schedule/ Inspection Frequency	6-1
6.2	Final Cover.....	6-1
6.2.1	Barrier Layer	6-1

6.2.2	Test Pad Construction	6-2
6.2.3	Top Vegetative Layer	6-3

Appendices

Appendix A	Asbestos Waste Shipment Record Form
Appendix B	Geotechnical Memorandum
Appendix C	EPA SOP 2015 Asbestos Sampling
Appendix D	EPA Asbestos Hazard Emergency Response Act (AHERA) Analytical Methods
Appendix E	Libby Montana Field Sample Data Sheets
Appendix F	CDM Federal Standard Operating Procedures (SOPs)
Appendix G	Baseline Groundwater Data for Monitoring Wells CDM-MW-7 and CDM-MW-8

Figures

Figure 1	Record Site Plan.....	2-2
Figure 2	Proposed Landfill Cell Layout	2-5
Figure 3	Landfill Operations Plan.....	3-2
Figure 4	Erosion and Sedimentation Plan.....	3-6
Figure 5	Soil Boring and Monitoring Well Locations.....	5-7

Section 1

Introduction

This Operations Plan has been prepared for the Lincoln County Class IV asbestos landfill, located in Libby, Montana. The landfill was designed and constructed for the purpose of the disposal of asbestos-containing material (ACM) generated during United States Environmental Protection Agency (EPA) emergency response actions and residential removals program for the Libby Superfund Site. The waste materials consist of double-bagged vermiculite, bulk vermiculite asbestos insulation, asbestos-containing soils, and asbestos contaminated demolition debris. The estimated quantity of asbestos waste to be disposed of at the Class IV landfill is 100,000 cubic yards (cy). The total estimated capacity required for the Class IV landfill is 150,000 cy (including 20 percent for future disposal needs and 25 percent for daily soil cover).

The design and construction of the landfill was administered as an EPA time-critical removal action. The landfill is located adjacent to the existing Lincoln County Class II and III solid waste landfill facility. A formal application and submittal process for a new waste unit was not required by the Montana Department of Environmental Quality (DEQ). However, the landfill design was reviewed by DEQ for compliance with all Appropriate and Applicable Regulations (ARARs), including the Administrative Rules of Montana (ARM) Sub-Chapter 5 Refuse Disposal solid waste regulations and state asbestos regulations. The design was approved by DEQ in a letter dated August 21, 2002 pending submittal of as-built drawings and this Operations Plan. Review comments on the Preliminary Landfill Operations Plan dated October 16, 2002 were received from DEQ on February 7, 2003 and are addressed in this Operations Plan. Additional applicable regulations include Chapter 40 of the Code of Federal Regulation (CFR), Subpart M, and the National Emission Standard for Asbestos.

This Plan includes the procedures for landfill operation, waste disposal, site security, record keeping, Closure Plan, Sampling and Analysis Plan, and Construction Quality Assurance/Construction Quality Control Plan.

A brief summary of the landfill design and construction is also provided.

Section 2

Landfill Construction

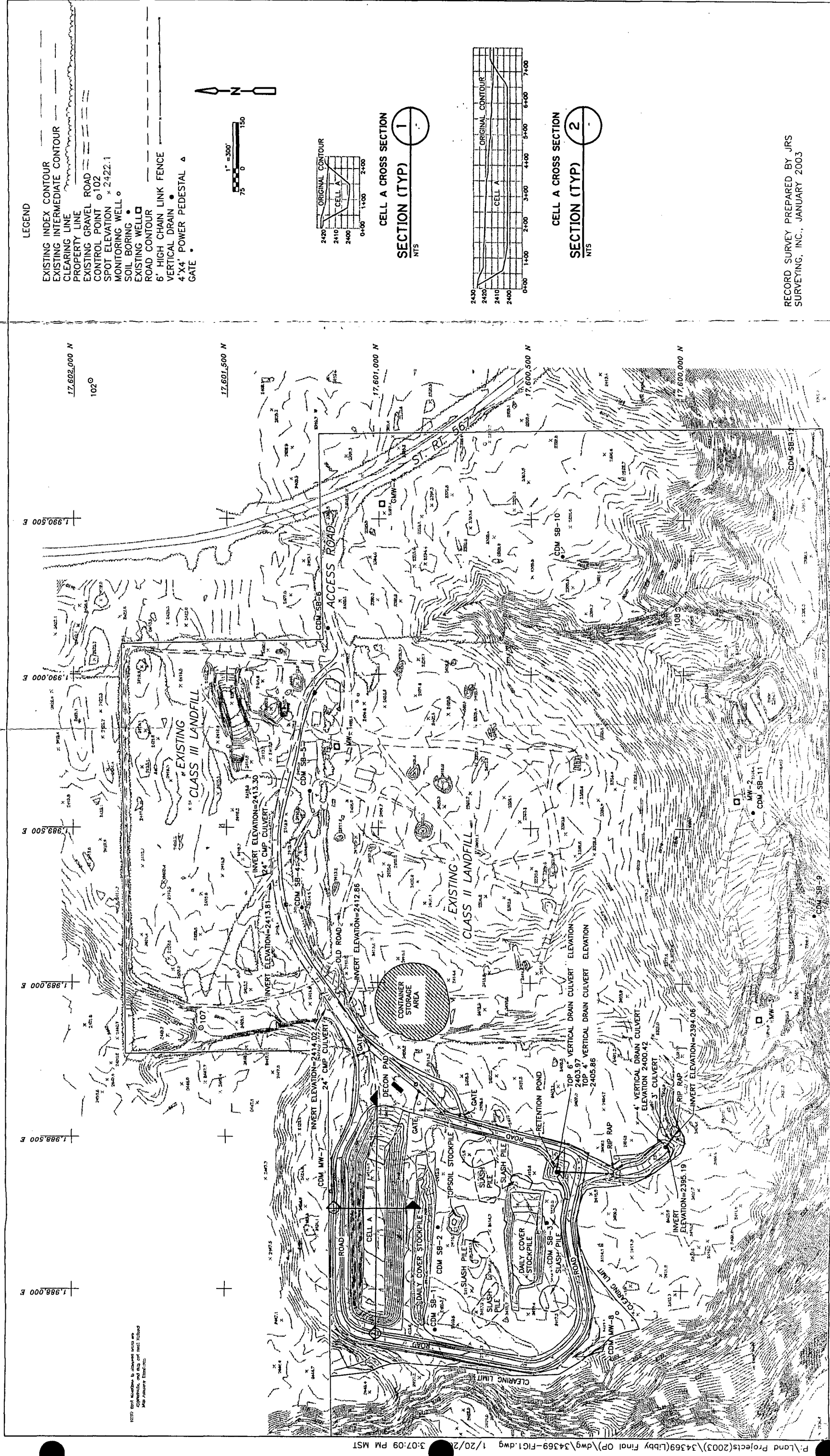
The Class IV asbestos landfill is located west of the existing Lincoln County Class II/III solid waste landfill. The location of the Class IV landfill, including landfill site features, is included as Figure 1. The waste disposal site consists of four unlined landfill cells, approximately 540 feet long by 175 feet wide by 20 feet deep. Waste will be disposed and covered daily starting at a depth of 20 feet below grade. Each landfill cell will be covered and closed to a depth of the existing grade. Drainage ditches will be installed between each cell and routed to a sediment pond south of the Class IV landfill.

The Class IV landfill was designed according to a "Phased Construction" approach, in which EPA can begin disposing ACM from the emergency response actions and residential removals program prior to completing of the construction of the four cells. New cells will be excavated as needed. The construction of the landfill was designed to be performed by a General Contractor working in Level D personal protective equipment (PPE). Operation of the landfill will be conducted in Level C PPE, by Occupational Safety and Health Administration (OSHA) 40-hour trained personnel. Level C PPE consists of an air-purifying respirator, tyvek suit, inner and outer gloves, hardhat, and disposable or dedicated overboots.

Lincoln County cleared all trees from the landfill cells footprint (cells A through D) and other features (road, decontamination pad, sediment ponds). The Contractor prepared the site by clearing remaining stumps following tree clearing and stockpiled them on future cells B and D footprints. During the summer of 2003, the dry stumps and wood debris will be burned by Lincoln County. The footprint of the first cell (cell A) was cleared to 2 feet below grade and the material was stockpiled for future use. Cell A was excavated to 20 feet below original grade and a ramp was built to access the interior of the cell. Sufficient excavated material to be used for daily cover and final cover was stockpiled; the remaining was transported to other areas of Lincoln County landfill. A road was constructed around the cells and the perimeter of the area was enclosed with a fence and two gates. Sediment ponds, culverts, and drainage ditches along the outside edge of the road were installed.

A temporary decontamination (decon) pad was installed for the decontamination of haul trucks and construction equipment. The temporary steel decon pad is located along the exit road, east of cell A. CDM recommends that the temporary steel decon pad be removed during the spring of 2003 and replaced with a concrete decon pad in the same location. A decon trailer located adjacent to the decon pad was installed to provide for personnel decontamination.

Each truck/vacuum truck will enter the cell and dump the load using the ramp on the east side of the cell. During disposal, water will be applied to the waste via a water truck. If necessary during the winter months, propylene glycol (PG) will be added to the water in the water truck at a ratio of 68 gallons PG to 100 gallons of water (100 percent PG). The additive will prevent water from freezing to a temperature of -20°C.



A minimum of once per day (when waste is accepted), or as needed, to prevent airborne ACM contamination 6 inches of cover will be placed on top of the waste materials. Personnel and vehicles that come into contact with ACM will be decontaminated prior to exiting the site. Once the cell is approximately 70 percent full, or as disposal demand estimates require, the next cell will be excavated, separated by a berm. This construction/operations plan was designed using the following assumptions:

- Waste materials to be disposed of in the Lincoln County Class IV landfill will be bulk vermiculite, asbestos containing soils, and general asbestos-contaminated construction debris generated from EPA's emergency response actions and residential removals program;
- The waste material will be delivered to the Class IV landfill in end dump trucks, vacuum trucks, or roll off containers;
- The approximate total ACM is 150,000 cy. This amount is based on an estimated volume of 100,000 cy (based on information from the EPA's removal project) plus a 20 percent contingency for future disposal needs, plus an allowance of 25 percent for daily cover soil and berms between cells;
- Although the Class IV landfill will be open to accept ACM year-round, landfill operations will slow during the winter months. Selected ACM will be stored in roll-off containers until sufficient volume is accumulated to be disposed at one time. Roll-off containers will be airtight.

The phased cell design and landfill operation plan provides several advantages over traditional open excavation, filling, and daily cover placement. The phased approach allows the Lincoln County Landfill to begin accepting asbestos waste relatively soon following the onset of construction, rather than waiting for the excavation of the entire landfill area. The proposed operation plan also offers flexibility with regard to closure. Once the residential asbestos removal program is completed, landfill operation can cease immediately, and proceed directly into the closure phase. The landfill cover system can be installed over only the cells used, potentially reducing the size of the Class IV landfill footprint.

The total volume of waste material used for this design is 150,000 cy. Assuming the removal actions will generate asbestos material for 5 years, approximately 30,000 cy per year will be disposed of in the landfill. The asbestos removal program is planned for 6 days per week, 12 months per year. Therefore, an average of 100 cy of asbestos waste material (including daily cover) will be disposed of in the landfill per day. This average will fluctuate depending on the weather conditions.

The volume of each cell is approximately 43,350 cy. The required capacity for the first year of asbestos waste disposal is approximately 70 percent of the first cell (30,000 cy/43,350 cy). Therefore an area of 540 feet by 200 feet, space for 1 cell, will be prepared for the first year and part of the second year of operation. The total landfill capacity is 173,400 cy (4 cells X 43,350 cy/cell). This capacity is greater than the anticipated asbestos waste generated from the removal actions (150,000 cy).

The details of the proposed landfill construction, specifically related to the sequencing of the landfill cells, are shown on Figures 1 and 2. Figure 1 depicts the site plan and location of the partially constructed Class IV landfill, cell A footprint and other features related to Phase I – Landfill construction. Figure 2 shows the site plan layout of the four cells. During Phase I, cell A was constructed while cells B, C, and D will be constructed during the Phase II operation. The layout and sequencing of the excavation of the landfill cells are depicted in Figure 2. The typical dimensions of each cell will be 175 feet wide, 540 feet long, and 20 feet deep (18 feet available for waste and daily cover, and 2 feet reserved for final cover material). Two cross sections of cell A are also included on Figure 1: north/south (section 1) and west/east (section 2). As shown on the cross sections, the sides of the cells will be excavated at a 2.5:1 slope.

According to the requirements of the ARM 17.50.530 Section 3, the final cover system must be designed with a minimum 18-inch soil infiltration layer (permeability no greater than 1×10^{-5} cm/sec) and a minimum 6-inch seed bed layer capable of sustaining native plant growth. The top six-inches of cleared material for cell A was stockpiled in the stockpile area for use as the final seedbed cover material. The remaining 1.5-feet of cleared material was stockpiled for use as daily cover at designated areas or as space allows. Prior to the acceptance of ACM, landfill construction will be performed in modified Level D PPE (steel-toe boots, hardhat, safety glasses, work gloves). Once operation of the Class IV landfill commences, the active asbestos waste disposal area will be designated an exclusion zone and all personnel and visitors will be upgraded to Level C PPE. Only OSHA (29 CFR 1910.120) trained personnel will be permitted within the exclusion zone. The public and County landfill employees will not be permitted in the active asbestos waste disposal area. During all phases of construction and operations, the Contractor must comply with OSHA 29 CFR.1920 for all construction safety matters with regard to excavation, heavy equipment operation. During landfill operations, the Contractor will comply with the Project Health and Safety Plan, supplemented by the Contractor's Health and Safety Plan addressing those activities that may not be addressed in the Project Health and Safety Plan. The Contractor's Health and Safety Plan will be reviewed and approved by the EPA On-Scene Coordinator, the Contracting Officer (CO), and/or the Contracting Officer's Technical Representative (COTR) before disposal operations can begin.

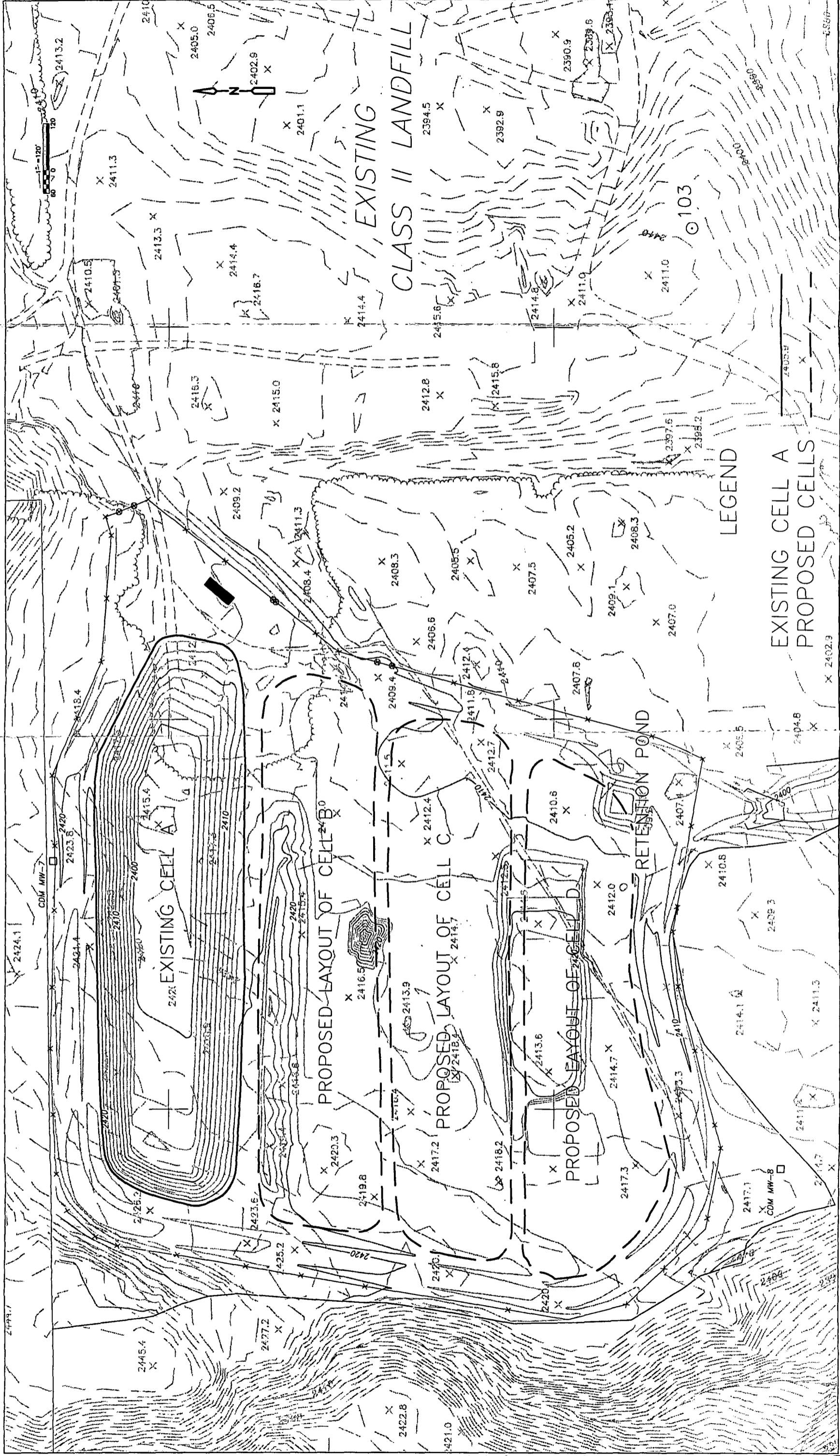


Figure No. 2
PROPOSED LANDFILL CELL LAYOUT

Section 3

Landfill Operations

3.1 Waste Disposal

The Class IV landfill will be open for waste disposal Monday through Saturday. Summer operating hours will be 9:00 a.m. to 6:00 p.m. and winter operating hours will be 8:30 a.m. to 5:30 p.m. The Class IV landfill will be staffed by the operations contractor when ACM disposal is planned. The Class IV landfill gates will be locked when the landfill is unattended. Figure 3 depicts the asbestos disposal operation plan.

Haul trucks and other Class IV landfill traffic will enter the Lincoln County property via the existing road to the Class II landfill, then bear onto the northern Class IV asbestos landfill access road. The Class IV landfill will be fenced at its perimeter with a locked gate to prevent unauthorized access. The fence line will also serve as the exclusion zone. All personnel entering the exclusion zone (including landfill operators, and visitors) must be OSHA trained and upgraded to Level C PPE in accordance with the Comprehensive Site Health and Safety Program. Trucks will be supplied with positive pressure units (PPU) and the drivers will not be allowed to exit the vehicle while in the exclusion zone.

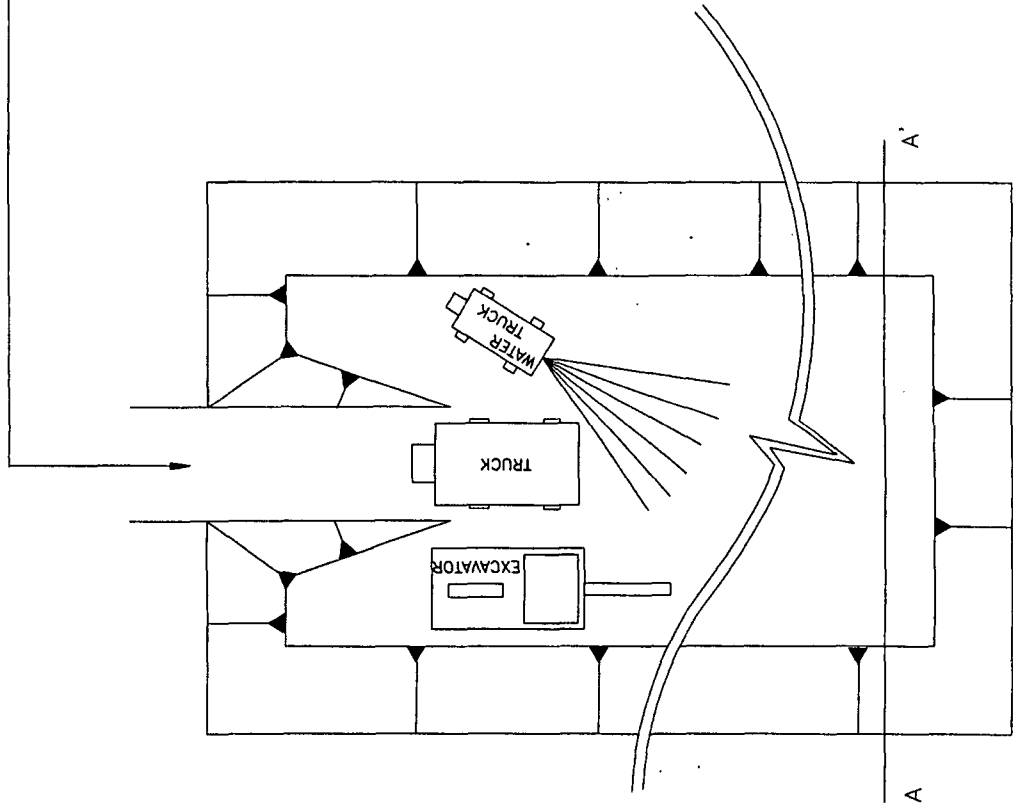
After entering the fenced landfill area, the haul trucks will drive into the cell via the cell ramp located on the east side of the cell. After disposing of the waste, the trucks will exit the cell and drive to the decon pad where it will be decontaminated before exiting the exclusion zone. Decontamination will be required for all portions of the truck that come into contact with the asbestos waste material. Truck traffic will be directed in the field by the operator. Asbestos waste material may also be stored temporarily in roll-off bins inside of the Lincoln County Landfill area (denoted as container storage area on Figure 1). Containers will be steel and will be airtight. In addition, the containers will be locked to minimize potential tampering. Using roll-off locking containers will allow less frequent dumping and decontamination and reduce the use of decon water and antifreeze at the site. Roll-offs will require decontamination after dumping and wastes will be covered after dumping as described in this plan. No more than 100 cy of waste will be stored in the storage area at any one time. Containers will be clearly labeled as asbestos waste.

The dedicated site water truck will apply water to the waste materials to prevent asbestos material from becoming airborne, and to control dust and litter. Water will be sprayed from the truck onto the waste material as it is dumped in the cell and following deposition. The application of water during waste disposal will be particularly important during the disposal of bulk vermiculite from vacuum trucks. During the winter months, propylene glycol will be added to the water in the water truck to prevent it from freezing. Care must be taken by the Contractor to ensure that all the vermiculite is disposed of into the cell and that no material is allowed to become airborne.

- NOTES:
1. LANDFILL IS AUTHORIZED TO RECEIVE ONLY CLASS III AND CLASS IV WASTE.
 2. NO ONE IS AUTHORIZED TO ENTER THE LANDFILL CELL WITHOUT PERMISSION OF THE GOVERNMENT.
 3. CONTRACTOR SHALL PROVIDE WATER FOR DAILY OPERATION. (WATER MUST BE CLEAR AND MEET EPA STANDARDS.)
 4. END DUMP NON-FRIABLE MATERIAL (CONSTRUCTION DEBRIS) DIRECTLY FROM THE ROLL-OFF CONTAINER INTO THE CELL.
 5. WET ACM UNTIL IT IS CAPPED WITH DAILY COVER.
 6. PLACE AND ARRANGE ACM WITH EXCAVATOR.
 7. PLACE AND COMPACT A MINIMUM OF 8 INCHES OF COVER SOIL AT EACH OPERATING DAY, NOT LEAVING ACM UNCOVERED OVER NIGHT.
 8. ALL PERSONNEL SHALL BE IN LEVEL C PPE WHILE HANDLING ASBESTOS.
 9. CONTRACTOR TO PROVIDE HEALTH AND SAFETY PLAN.
 10. OPERATIONS TO STOP DURING PERIODS OF WIND THAT COULD CAUSE VISIBLE AIRBORN CONTAMINATION.

ACM - ASBESTOS CONTAINING MATERIAL

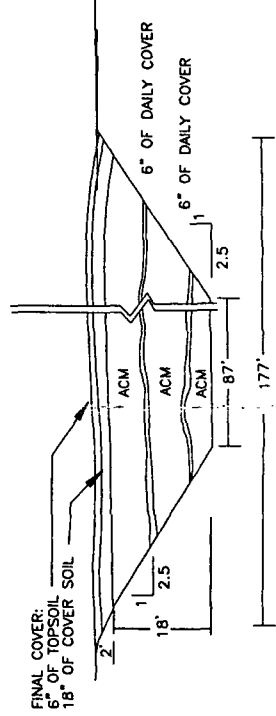
COMPLETE ALL PAPER WORK PRIOR TO DISPOSAL AT THE ASBESTOS CELL.



TYPICAL LANDFILL CELL

- NOTE:
1. ASBESTOS CONTAINING MATERIAL SHALL BE DISPOSED OF FROM TRUCKS, ROLL-OFFS, OR VACUUM TRUCKS.

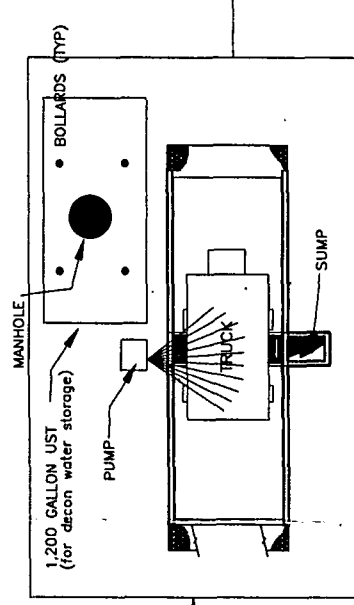
FINAL CELL CROSS SECTION PROFILE



- NOTES:
1. EXCAVATOR REARRANGES ACM MATERIAL.
 2. COMPACTION.

EXIT LANDFILL

DECONTAMINATION PAD



- NOTES:
1. DECONTAMINATE EQUIPMENT.
 2. DISPOSE OF SEDIMENT AND WATER IN CLASS IV LANDFILL.
 3. CLEAN SUMP AS NEEDED.
 4. ALL PERSONNEL IN CONTACT WITH ACM SHALL BE DECONTAMINATED AT THE DECONTAMINATION TRAILER.
 5. CONTRACTOR TO SUPPLY PUMP AND PRESSURE WASHER FOR USE IN DECONTAMINATION OF EQUIPMENT, HAUL TRUCKS, PERSONNEL AND WATER.

An excavator will distribute the waste in uniform lifts before placing a 6-inch layer of daily cover soil (obtained from the soil stockpile located adjacent to the cell) over the waste materials. At a minimum of once per day, 6 inches of cover soil will be applied over the waste material with the excavator. No ACM shall be left uncovered overnight. Additional applications of cover soil may be required to prevent dust or debris from becoming airborne. Once the cover soil has been applied, the waste/soil will be compacted with an excavator or bulldozer.

Once a landfill cell is approximately 70 percent filled or demand requires, the next cell to the south will be excavated. The excavator bucket, and the tracks, if they have been in contact with ACM, will be decontaminated at the decon pad prior to the start of excavation of the next landfill cell.

A container will also be located in the container storage area for the disposal of ACM generated from home/commercial renovation or other non-Libby Superfund site project related activities. Lincoln County residents wanting to dispose of ACM must contract with a licensed asbestos contractor for the transportation and disposal of the ACM. The licensed asbestos contractor must contact the Lincoln County Sanitation Department for approval prior to bringing properly packaged ACM to the landfill. The container will have a 25 cubic yard capacity and will be the same model as the containers used by the landfill operator to ensure compatibility with disposal roll-off trailers. The Lincoln County Landfill staff will be responsible for maintaining the disposal container, including security (locking and holding the key), maintaining records of the materials disposed of in the container, and ensuring that only ACM is placed in the container and that all ACM is properly packaged. The container will be labeled "Asbestos." On scheduled disposal days, the Class IV asbestos landfill operator will empty the container into the Class IV asbestos landfill as described in this plan, and returned the container to the container storage area following decontamination.

State and federal regulations dictate elements of Class IV and active asbestos waste disposal site operation including site security, waste screening, and record keeping. This operational plan describes the procedures to be followed during operation of the Lincoln County class IV landfill in the following sections. According to ARM 17.50.511(3), Class IV landfills must be designed, constructed, maintained and operated so as to control litter, insects, rodents, odor, aesthetics, residues, wastewater, leachate, and air pollutants. The following subsections describe the methods by which the landfill will be operated in order to comply with these regulations.

3.2 Dust and Airborne Particulate Control

ACM will be transported to the landfill in roll off box containers, end dump truck, or vacuum trucks. During all phases of transportation, unloading, placement of waste, and covering of asbestos-containing wastes, no visible air-borne contamination will be permitted to outside air. Landfill air monitoring will be performed by the COTR's air monitoring team subcontractor as described in Section 5.1. A weather station will be installed on-site to log temperature, wind speed and wind direction. Perimeter air

sampling units will be located at the fence line of the disposal site. Perimeter air samples will be collected prior to landfill operation to obtain a baseline of the site air conditions. Air samples will be collected during the first three disposal days and yearly thereafter to monitor site disposal activities. A description of the air sampling requirements is provided in the Sampling and Analysis Plan (Section 5).

A dedicated site water truck will be available at all times to water down the waste material during and following disposal in the landfill in the event of dust generation and visible airborne particulates. During the winter months, PG may be added to the water truck to prevent freezing. The PG will be stored in an above ground storage tank adjacent to the decon pad/building.

A gravel road around the landfill perimeter provides access to the cells within the Class IV landfill. A gravel haul road running north of the Class II landfill provides access through the Lincoln County property to the Class IV landfill. This access road is separate from the Class II landfill access road. Magnesium chloride will be applied to the haul and perimeter roads following their construction. During landfill operation, the roads will be watered to prevent generation of dust. If watering methods are not successful in eliminating dust or other particulate matter, landfill operations will cease until conditions for operation improve.

Generation of dust and airborne asbestos material will be prevented by water missing and the application of 6 inches of cover soil over the waste material. The cover soil will be applied at least daily during periods of landfill operation in accordance with 40 CFR 61.154(c)(1). The application of daily cover will also control litter, disease vectors, and improve aesthetics at the landfill. The soil excavated from the individual cells will be stockpiled adjacent to the cell to use as the daily cover. In the event that the soil stockpiles become frozen during the winter months, other undisturbed areas within the Class IV Landfill will be available for daily cover.

3.3 Stormwater and Erosion Control

According to ARM 17.50.511 (1)(k)(l) runoff from the active landfill must not cause a discharge of pollutants into waters of the US, including wetlands, that violates any requirements of the Federal Clean Water Act, including NPDES and MPDES or that causes the discharge of a non-point source of pollution to waters of the US, including wetlands, that violates any requirement of an area-wide or state-wide water quality management plan that has been approved under Section 208 or 319 of the Federal Clean Water Act, as amended.

A run-on control ditch and a run-off stormwater drainage ditch were constructed on the outside and inside of the gravel access road to and surrounding the landfill, respectively. The ditches will channel stormwater off the road and away from the waste disposal site and toward a series of stormwater retention ponds located southeast of the Class IV landfill. The primary sediment pond is located in the southeast corner of the Class IV landfill footprint. Sediment from within the landfill disposal area will settle within this pond and water will be channeled via a culvert

under the road toward a secondary sediment pond. Sediment will settle in the secondary sediment pond and the water will be diverted through a culvert, under a dam, to the Lincoln County landfill ditch.

Erosion control fencing will be installed and maintained on the down-slope side of all soil stockpiles. The erosion control fencing will be filter fabric sediment barrier or equivalent. Landfill stormwater and erosion control features are shown on Figure 4.

During the construction of cell 4, the primary sediment pond and approximately 50 feet of culvert connecting the ponds will be removed. The cover system for the cells is designed to channel any stormwater runoff toward the drainage ditch. Upon final closure of the landfill, the secondary sediment pond will be removed, and stormwater will be channeled into the Lincoln County landfill ditch.

3.4 Decontamination

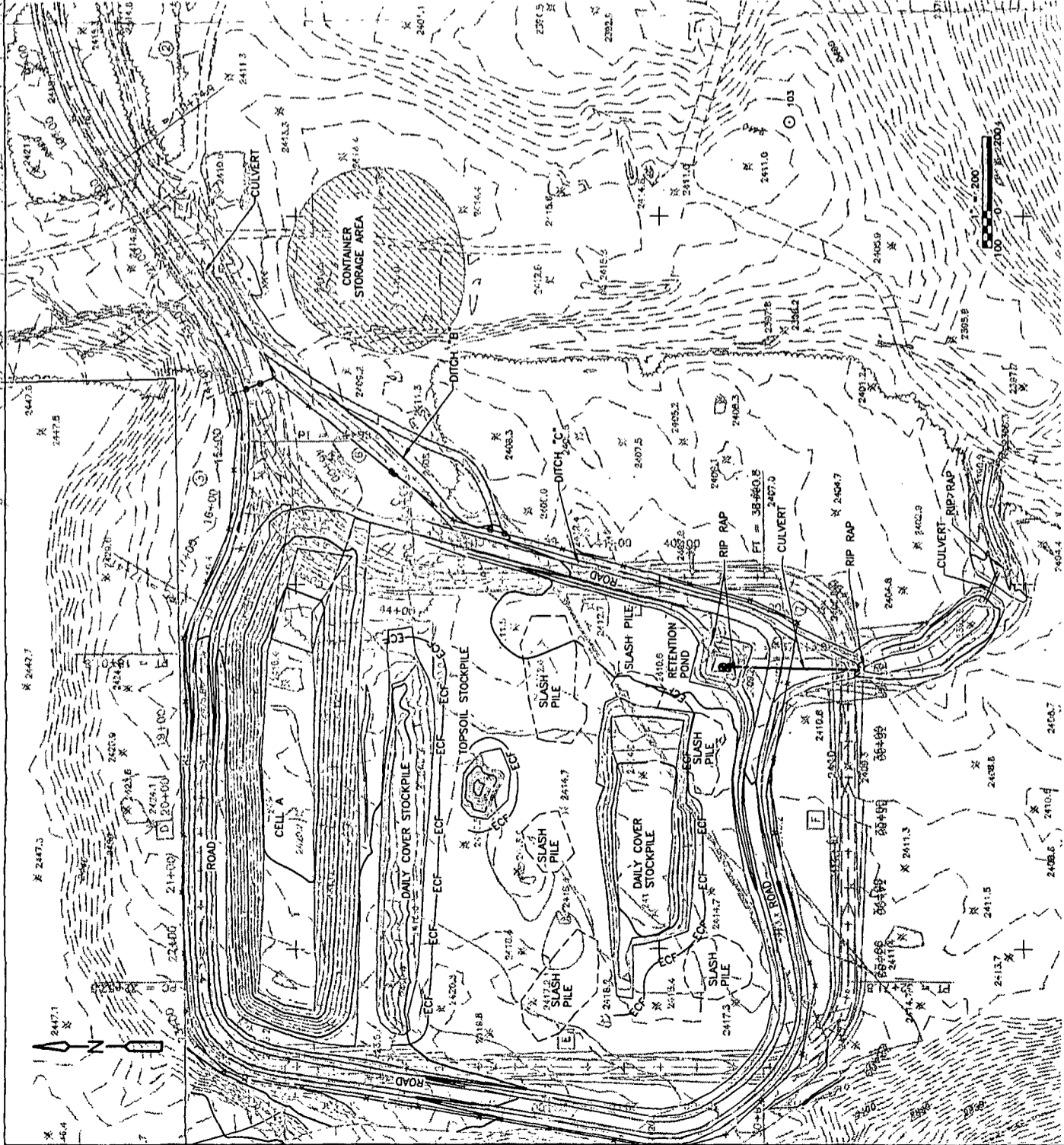
All haul trucks and construction equipment exiting the active asbestos waste disposal cell will be decontaminated prior to leaving the exclusion zone. All personnel working in the exclusion zone will be required to go through a personnel decon prior to leaving the site.

The decon pad is located along the Class IV landfill haul road, at the northeast corner of the landfill. A steel decontamination (decon) pad, previously used at another removal site in Libby, was installed for the decontamination of haul trucks and construction equipment. Should winter operations be slowed with the steel decon pad, it will be removed and replaced with a concrete decon pad at the same location.

In a letter to the Volpe Center dated October 20, 2002, CDM identified two options for winter decontamination of truck and construction equipment. These options are:

1. Constructing a heated pole barn around the decon pad to shelter personnel and equipment from the elements and to prevent freezing of decontamination water. The building will be heated by propane to prevent the decontamination water from freezing.
2. Adding PG to the decontamination water to prevent freezing.

The Government has elected to use PG, if necessary during winter operations. Decontamination may include truck beds and truck tires, depending on contact with ACM, as well as the tracks and bucket of the excavator or dozer used to move the waste materials within the cells. The concrete decon pad shall be a permanent 50-foot long by 30-foot wide concrete pad, with a 800-gallon sump to collect all decontamination water. The Contractor will periodically clean out the sediment and used decon water from the sump and dispose of the materials in the active landfill cell. Water for decontamination will be contained in a 1000 gallon underground storage tank. The tank will be filled as needed via the dedicated site water truck. There is no water source available on the Lincoln County property. All decon water,

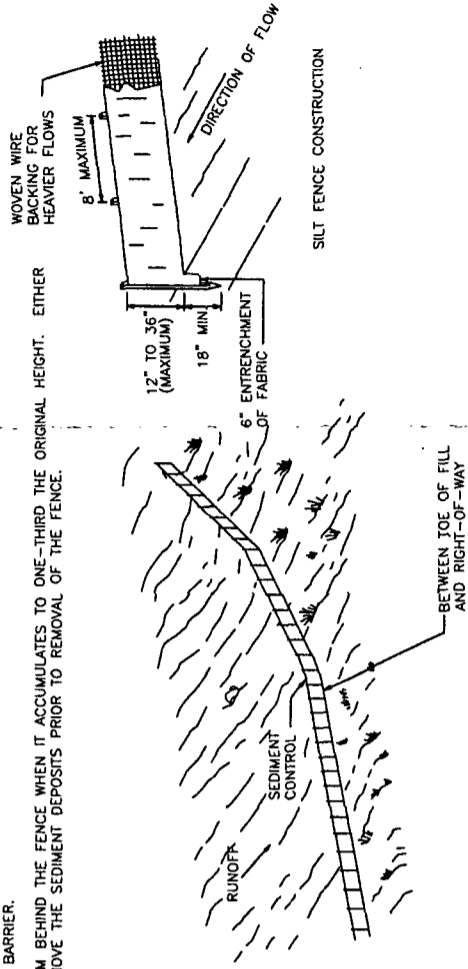


LEGEND
EXISTING INTERMEDIATE CONTOUR
EXISTING INDEX CONTOUR
EXISTING CONTROL POINT
EXISTING GRAVEL ROAD
EXISTING TREE LINE
NEW DITCH
EROSION CONTROL FENCE - ECF
ACCESS ROAD CENTERLINE
STRAW BALE LOCATIONS (EVERY 300 FT) ◇

NOTE:
1. CONDUCT ROUTINE MAINTENANCE ON SEDIMENT PONDS:
- INSPECT WEEKLY AND AFTER STORM EVENT.
- REMOVE SEDIMENT WHEN SEDIMENT STORAGE ZONE IS HALF FULL.
2. MAINTAIN EROSION CONTROL FENCING ON DOWN SLOPE SIDE OF ALL SOIL STOCKPILES AS SHOWN ON PLAN.

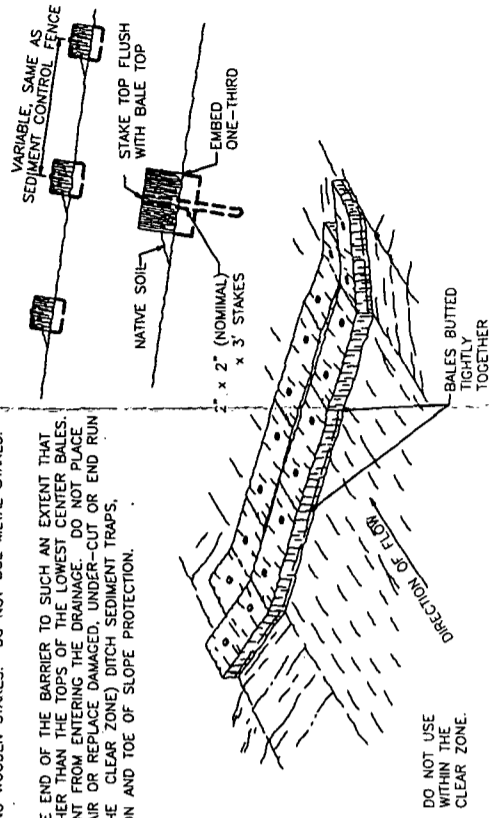
SURVEY PREPARED BY JRS SURVEYING, INC., JANUARY 2003

1. EROSION CONTROL FENCE (ECF) IS A SINGLE OR SERIES OF FILTER FABRIC SEDIMENT BARRIER STRETCHED AND ATTACHED TO SUPPORTING POSTS. THE FENCE BOTTOM IS ENTRENCHED.
2. EROSION CONTROL FENCES ARE USED FOR SHEET OR CONCENTRATED FLOWS TO ASSIST IN SEDIMENT CONTROL BY RETAINING SOME OF THE ERODED SOIL PARTICLES AND SLOWING THE RUNOFF VELOCITY TO ALLOW PARTICLE SETTLING. APPLICATIONS INCLUDE DITCH PROTECTION TRAPS, WATER RESOURCE PROTECTION, INLET/OUTLET PROTECTION, BANK PROTECTION, TOE OF SLOPE PROTECTION AND CHANNEL CHANGES. INSTALL EROSION CONTROL FENCES PRIOR TO DISTURBING AREAS REQUIRING THIS BMP OR AS SLOPE GRADES ARE ACHIEVED. MAXIMUM CUT OR FILL SLOPE FOR A EROSION CONTROL FENCE IS 2:1. USE 2 INCH BY 2 INCH (NOMINAL) WOODEN STAKES. DO NOT USE METAL STAKES.
3. POSITION THE BARRIER TO PREVENT SEDIMENT FROM ENTERING THE DRAINAGE. DO NOT PLACE THE BARRIER ACROSS LIVE STREAMS. WOVEN WIRE BACKING IS NECESSARY WHEN DEALING WITH HEAVIER FLOW VELOCITIES AND SEDIMENT. DO NOT USE STRAW BALE BARRIERS INSIDE THE CLEAR ZONE. STRAW BALES MUST BE CERTIFIED WEED-FREE.
4. REMOVE SEDIMENT FROM BEHIND THE FENCE WHEN IT ACCUMULATES TO ONE-THIRD THE ORIGINAL HEIGHT. EITHER GRADE AND SEED OR REMOVE THE SEDIMENT DEPOSITS PRIOR TO REMOVAL OF THE FENCE.



TYPICAL EROSION CONTROL FENCING INSTALLATION DETAILS

1. STRAW BALE BARRIER (SBB) IS A SEDIMENT BARRIER CONSISTING OF ENTRENCHED, OVERLAPPING AND ANCHORED STRAW BALES TO REDUCE RUNOFF VELOCITIES AND RETAIN SEDIMENT. DO NOT USE STRAW BALE BARRIERS INSIDE THE CLEAR ZONE. STRAW BALES MUST BE CERTIFIED WEED-FREE.
2. STRAW BALE BARRIERS ARE USED FOR SHEET OR CONCENTRATED FLOWS TO REDUCE RUNOFF VELOCITY, PROMOTE SEDIMENT RETENTION AND ALLOW SETTLING. ENTRENCH THE BARRIER APPROXIMATELY ONE-THIRD OF THE BALE'S HEIGHT AND BACKFILL ON THE UPHILL SIDE. USE 2 INCH BY 2 INCH (NOMINAL) BY 3 FOOT LONG WOODEN STAKES. DO NOT USE METAL STAKES. USE A MINIMUM OF TWO STAKES PER BALE.
3. AS A DITCH SEDIMENT TRAP, EXTEND THE END OF THE BARRIER TO SUCH AN EXTENT THAT THE BOTTOMS OF THE END BALES ARE HIGHER THAN THE TOPS OF THE LOWEST CENTER BALES. POSITION THE BARRIER TO PREVENT SEDIMENT FROM ENTERING THE DRAINAGE. DO NOT PLACE THE BARRIER ACROSS LIVE STREAMS. REPAIR OR REPLACE DAMAGED, UNDER-CUT OR END RUN BALES. APPLICATIONS INCLUDE OUTSIDE THE CLEAR ZONE) DITCH SEDIMENT TRAPS, INLET/OUTLET PROTECTION, BANK PROTECTION AND TOE OF SLOPE PROTECTION.



TYPICAL STRAW BALE INSTALLATION DETAILS

Figure No. 4
EROSION AND SEDIMENTATION PLAN

as well as water for dust control of waste and on roads must be obtained by the Contractor from an approved location. A decon trailer is located adjacent to the decon pad to provide for personnel decontamination. Hot and cold water to be used to decontamination is provided to the decon trailer. Personnel decontamination shall be conducted in accordance with the Comprehensive Site Health and Safety Program Plan. All disposable PPE shall be collected in double bags and disposed of in the landfill.

3.5 Health and Safety

As described above, all work during the operation of the asbestos waste disposal site will be conducted in Level C PPE. Only OSHA trained employees will be permitted within the active asbestos waste disposal area. The public and County government officials who are not OSHA trained will not be permitted in the disposal area. All work during landfill operation will comply with the Comprehensive Site Health and Safety Program. The Contractor will prepare a site specific Health and Safety Plan (HASP) for all work not included in the Comprehensive Site Health and Safety Program Plan. Minimum required elements of the site specific HASP are as follows:

- Delineation of work zones including exclusion zone, contamination reduction zone, and support zone;
- Description of site hazards and contaminants (asbestos);
- Identification of Site Health and Safety Coordinator;
- Description of Level C PPE, to include the use of air purifying respirators with P100 cartridges in the exclusion zone;
- Any site field monitoring to be performed;
- Personnel and equipment decontamination procedures;
- Emergency contact names and phone numbers; and
- Signature page signed by all site personal indicating that HASP is understood and will be complied with.

Personnel air monitoring will be performed by the COTR's air monitoring team subcontractor. At the onset of landfill operation, a task-based exposure assessment will be performed for personnel engaged in each work activity. Personnel air monitoring will be conducted at a frequency based on the results of the assessment in accordance with OSHA regulations.

Additionally, all personnel engaged in work at an asbestos disposal site must meet the requirements for accreditation and permitting outlined in ARM 17.74.314.

3.6 Site Security

ARM 17.50.511(1)(c) states that Class IV landfills must be fenced to prevent unauthorized access and must be supervised when open. Likewise, according to 40 CFR 61.154(b), fencing must be installed and maintained in a manner adequate to deter access by the general public. The federal asbestos regulations require that warning signs be displayed at all entrances and at intervals of 330 feet along the perimeter of the site where asbestos-containing waste material is deposited. The signs must be posted in accordance with 40 CFR 61.154(b)(1).

The Lincoln County Class IV asbestos waste landfill is fenced at the perimeter with a 6-foot high chain-link fence with three strands of barbed wire segregating the Class IV landfill from the Lincoln County Class II landfill. Additionally, temporary orange construction safety fence segregates the active landfill cell (and the exclusion zone) from the remaining landfill area. A metal swinging gate provides access to the landfill. The landfill will be staffed while ACM disposal is planned. When the landfill is closed, the gate will be locked. Signage will be installed in compliance with 40 CFR 61.154(b)(1). Fencing and signage will be maintained during active waste disposal, closure, and post-closure.

3.7 Waste Screening

The Lincoln County Class IV landfill can accept the following categories of wastes:

1. Group III Wastes: include wood and non-water soluble solids. These wastes are characterized by their general inert nature and low potential for adverse environmental impacts. These wastes include inert solid waste such as unpainted brick; dirt, rock, concrete; clean untreated and unglued wood material; brush; unpainted or untreated lumber; vehicle tires; and industrial mineral wastes which are essentially inert and non-water soluble and do not contain hazardous waste constituents.
2. Group IV Wastes: include construction and demolition debris, and asphalt.

The Class IV landfill is not permitted to accept Group II wastes which include decomposable wastes. ARM 17.50.511 prohibits the acceptance of the following materials at Class IV landfills:

- Regulated hazardous waste/PCB wastes;
- Bulk or noncontainerized liquid waste, unless approved in advance by DEQ or the waste is a household waste (other than septic); and
- Containerized liquid waste, unless the container is small and similar in size to that normally found in household waste, the container is designed to hold liquids for use other than storage, or the waste is a household waste.

According to ARM 17.50.511 (1)(e), the operator must implement a program for detecting and preventing the disposal of regulated hazardous waste/PCB wastes. The waste-screening program must include:

1. Random inspection, unless other steps are taken to ensure that incoming loads do not contain hazardous waste/PCB waste;
2. Records of inspections;
3. Training of personnel to recognize regulated hazardous waste/PCB waste; and
4. Notification to DEQ if regulated hazardous/PCB waste is discovered at the facility.

3.8 Record Keeping

Currently, there is no weigh station at the Lincoln County landfill. All waste loads arriving at the facility for disposal will be tracked via the Waste Shipment Record (WSR). The WSR should be maintained using a form similar that shown in Appendix A. The landfill operator will inspect random waste loads in accordance with the previous section. In accordance with 40 CFR 61.154(e), the landfill operator will verify the information on each load's WSR to ensure that the information on the WSR accurately describes the waste shipment with regard to quantity and proper enclosure of the load.

The landfill operator must verify that the information in WSR Item 6 (number and type of waste containers) coincides with the quantities reported in Item 7 (cubic yards of waste). If there is any discrepancy between the waste load quantity recorded on the WSR and the quantity observed in the load, the landfill operator must make note of the discrepancy in Item 12 of the WSR. The landfill operator should make an attempt to reconcile the discrepancy between the waste shipment record and the waste received with the waster generator. If the discrepancy is resolved, it should be noted on the WSR. If the discrepancy cannot be resolved within 15 days of receipt of the waste, a discrepancy report must be sent to the agency responsible for the generation of the waste and the landfill site (EPA). The report should describe the discrepancy and steps taken to resolve it along with a copy of the WSR.

If inspection of the waste load indicates that that a significant amount of improperly enclosed or uncovered waste exists, note must be made in Item 12 of the WSR and a written report including a detailed description of the situation and a copy of the WSR submitted to EPA.

Once the loads have been examined, and discrepancies noted, the landfill operator must complete Item 13 (Certification of Receipt) of the WSR, then inform the generator of receipt of the load by sending a copy of the WSR to the waste generator no longer than 30 days after receipt of the waste. Copies of the WSRs must be

maintained by the landfill operator for a period of 2 years in accordance with 40 CFR 61.154(e)(4). Copies should be made available for inspection during business hours.

The waste disposal operator must maintain records of the location, depth and area, and quantity in cubic yards of asbestos containing waste in the disposal site on a map of the disposal area.

40 CFR 61.154(e) and 17.50.511(1)(p) specify the requirements of records to be maintained by the landfill. For all asbestos-containing waste material received, the owner/operator of the landfill shall maintain waste shipment records including, at a minimum:

1. The name, address, telephone number of the generator;
2. The name, address and telephone number of the transporter;
3. The quantity of the asbestos-containing material in cubic yards;
4. The presence of improperly enclosed or uncovered waste; and
5. The date of receipt.

Records maintained by the landfill must also include:

1. Inspection records, training procedures, results and information from the comprehensive employee health monitoring plan, and notification procedures;
2. Any demonstration, certification, finding, monitoring, testing, or analytical data required by department groundwater monitoring regulations found in ARM 17.50.701;
3. Closure and post closure care plans;
4. Cost estimates and financial assurance documentation; and
5. Any waste quantity records.

The operator must retain records at the landfill in an alternate location approved by DEQ. Duplicate landfill records will be kept in a separate location, at the Lincoln County Environmental Health office. The owner/operator must notify the DEQ when documents have been placed or added to the record. All information must be made available for inspection by DEQ and the public. According to ARM 17.74.341, records must be maintained and made available to DEQ when requested, for 30 years.

According to 40 CFR 61.154(h)(i), the operator must, upon closure, submit a copy of the records of asbestos waste disposal locations and quantities to the EPA Administrator. All records must be made available to the EPA administrator during regular business hours.

If, for any reason, the operator plans to excavate or otherwise disturb any asbestos containing waste that has been disposed and covered at the landfill, the operator must notify the EPA and DEQ at least 45 days prior to the disruptive activity. In accordance with 40 CFR 61.154(j), notification must include:

1. Starting and completion dates;
2. Reason for disturbing the waste;
3. Methods for controlling emissions during excavation, storage, transport and disposal; and
4. Location of temporary storage area and final disposition site.

The volume of the waste materials disposed of in the landfill will be estimated through quarterly in-place surveying. The empty as-built landfill cell A has been surveyed. On a quarterly basis, the cell will be surveyed to determine the volume placed in the cell. Each cell, to be constructed as needed, will be surveyed prior to waste placement and quarterly once disposal commences.

3.9 Methane Gas Generation

According to ARM 17.50.511(1)(f), the operator must ensure that methane gas generated does not exceed 25 percent of the lower explosive limit (LEL) for methane in facility structures and that methane does not exceed the LEL at the facility property boundary. Due to the inert quality of the waste materials accepted at the Lincoln County Class IV landfill, it is not anticipated that significant quantities of methane gas will be generated. Most of the waste to be accepted is expected to be inorganic wastes such as vermiculite, soil, and concrete. However, some wood waste from structures will be accepted as well. Distances from structures and the location of the landfill from such structures is significant. Therefore, unless the classification of the landfill changes over the period of landfill operation, or unless significant development occurs adjacent to the landfill, an exemption from monitoring methane gas is requested.

Section 4

Closure Plan

This closure plan has been prepared in accordance with ARM 17.50.530(3)(c) and describes the steps necessary to close the landfill unit at any point during its active life. This plan includes:

1. A description of the final cover, designed in accordance with 17.50.530(3)(a) and the methods and procedures to be used to install the cover;
2. An estimate of the landfill area that the DEQ determines to be the largest active portion of the facility ever requiring a final cover during the active life of the facility;
3. An estimate of the maximum inventory of wastes ever on-site over the active life of the landfill facility; and
4. A schedule for completing all activities necessary to satisfy the closure criteria.

Prior to closing the landfill, the owner/operator must notify the DEQ that a notice of intent to close the unit has been placed in the operating record 17.50.530(3)(e). Closure activities must begin no later than 30 days after the date the landfill receives the known final receipt of wastes. If the unit has remaining capacity and there is likelihood that the unit will receive additional wastes, then closure must begin no later than 1 year after the most recent receipt of wastes. Extensions beyond 1 year may be granted by DEQ if the owner/operator demonstrates that the unit has the capacity to receive additional wastes and all steps necessary have been taken to prevent threats to human health and the environment from the unclosed unit. Any portion of the unit that will not receive additional waste within 180 days must have an intermediate cover of at least 1 foot of approved earthen materials.

Closure must be completed in accordance with the closure plan within 180 days following the beginning of closure as specified above. DEQ may grant an extension if the owner/operator demonstrates that closure will, of necessity, take longer than 180 days and if the owner/operator has taken all steps necessary to prevent threats to human health and the environment from the unclosed unit.

4.1 Cover Design

The Lincoln County Class IV landfill final cover is designed in accordance with ARM 17.50.530(3)(a) to minimize infiltration and erosion. The final cover will:

1. Minimize infiltration through the closed unit by the use of a barrier layer that contains a minimum 18 inches of earthen material and has a permeability no greater than 1×10^{-5} cm/sec;

2. Minimize erosion of the final cover by the use of a seed bed layer that contains a minimum of 6 inches of earthen material that is capable of sustaining native plant growth; and
3. Contain a revegetated cover with native plant growth applied within 1 year of placement of the final cover. Seed mix is specified in Section 6.

The final cover will be installed with a crown and a minimum 2 percent slope. Drainage channels will be installed to route stormwater toward the run-off control ditches and series of stormwater ponds. The phased landfill design approach allows for the application of the final cover at any time during the operating life of the landfill. The 2 feet of soil initially removed and stockpiled will be used as the final cover soil. The maximum area of the landfill requiring final cover will be 840-feet by 540-feet, or 453,600 square feet. The maximum volume of waste material disposed of in the landfill will be approximately 173,400 cy. Three undisturbed samples of the landfill foundation soils were collected for permeability testing (ASTM D5084). Permeability ranged from 2.1×10^{-6} to 9.4×10^{-4} cm/sec. Results of the laboratory testing are included in the Geotechnical Memorandum, attached as Appendix B.

In accordance with 40 CFR 61.154(h)(i), a copy of the records of asbestos waste disposal locations and quantities which have been maintained on the disposal site map will be submitted to the EPA Administrator. Likewise, an estimate of the active inventory of wastes ever on-site during the active life of the facility will be submitted to DEQ in accordance with ARM 17.50.530(3)(c)(iii).

4.2 Post Closure

Upon closure, the provisions of 40 CFR 61.151 must be complied with. These provisions include operational provisions including maintaining at least 6 inches of compacted, non-asbestos containing material and vegetative cover, fencing, and signage. In addition, a notation must be placed on the deed to the landfill property within 60 days after the site becomes inactive. The notation would notify any potential purchaser of the property that the land has been used for the disposal of asbestos waste.

If at any point asbestos containing material that has been deposited and covered at the landfill must be excavated or disturbed, the EPA Administrator must be notified in writing at least 45 days prior. The notice should be in accordance with 40 CFR 61.154(j).

Section 5

Sampling and Analysis Plan

This section presents the Sampling and Analysis Plan (SAP) developed in preparation for the monitoring to be performed during the operation of the Lincoln County Class IV Asbestos Landfill in Libby, Montana. The primary purpose of this plan is to summarize the sampling requirements for asbestos in ambient air during landfill operations air and groundwater monitoring.

5.1 Air Monitoring

According to ARM 17.50.511(1)(i), the owner/operator of a landfill unit must ensure no violation of requirements developed under the state implementation plan (SIP) approved or promulgated by the EPA administrator pursuant to Section 110 of the Clean Air Act as amended. Air monitoring requirements for asbestos projects are also included in ARM 17.74.338, Asbestos Abatement Project Control Measures.

Air monitoring during landfill operations will be performed by the COTR's team subcontractor who will supply all required air monitoring stations, sampling equipment, and personnel.

5.1.1 Meteorology

A Meteorological station will be established on-site for weather data collection for one month prior to disposal of ACM in the landfill. Weather data will help to support the degree that samples were actually downwind and verify that the sample locations represent the worst-case airborne asbestos concentrations. Meteorological parameters that will be monitored are temperature, wind speed, wind direction and sigma theta (which is the horizontal wind direction standard deviation and an indicator of atmospheric stability). Wind speed is a critical factor in determining the potential migration of asbestos fibers from the landfill cell. Wind direction can highly influence the path of airborne asbestos. Atmospheric stability refers to the degree to which the atmosphere tends to dampen vertical and horizontal motion. Stable atmospheric conditions (i.e., evenings) result in low dispersion, and unstable atmospheric conditions (i.e., hot sunny days) result in higher dispersion.

Two weeks of weather data will be gathered from a weather station equipped with a data logger to record temperature, wind speed, wind direction at the landfill before operations commence. Sigma theta will be calculated from the data collected. Atmospheric stability will be documented daily when air samples are collected. Prevailing wind direction is particularly important when selecting monitoring locations for potential asbestos release from a fixed source, or in this case the landfill.

5.1.2 Ambient Sampling Stations

During the first three days of landfill operations, the exclusion zone will be monitored for asbestos migration by collecting ambient air samples at established sample stations. If initial ambient air sampling results indicate the Government Contractor's engineering control adequately reduce the limits of airborne asbestos fibers to

acceptable levels, perimeter air monitoring will be conducted once per year thereafter. Ambient air sampling will be conducted in accordance with EPA SOP 2015 (Appendix C). Samples will be collected during the first three ACM disposal days at the landfill and yearly thereafter. The location of the sample stations will be selected as follows:

Table 1 Selecting the location of the samples stations at the Lincoln County Landfill

Sample Station Location	Sample Numbers	Rationale
Upwind/Background	Collect a minimum of two simultaneous upwind/background samples 30° apart from the prevailing wind-lines.	Establish background levels
Downwind	Collect a minimum of 3 sample stations in a 180° arc downwind from the landfill.	*Indicates if asbestos is leaving the site.
Worst Case/Personal Breathing Zone	**Obtain a personal breathing zone sample on an employee working in the exclusion zone.	Verify and continually confirm and document selection of proper levels of worker protection.

* Special attention will be paid to the downwind sample station locations

** This personal breathing zone sample will represent a worst-case ambient fiber concentration at the landfill cell.

5.1.3 Personal Breathing Zone Air Sampling

During landfill operations, personal breathing zone air samples will be conducted in accordance with OSHA 1926.1101. An exposure assessment will be completed at the initiation of the landfill operation to ascertain expected exposures. This assessment will be completed to provide information necessary to assure that all planned control systems are appropriate for the operation and work properly. Representative 8-hour time weighted average (TWA) task-based exposures will be determined on the basis of air samples representing full-shift exposures. The OSHA permissible exposure limit (PEL) for 8-hour TWA employee exposure is 0.1 f/cc by phase contrast microscopy (PCM). Evaluation of the landfill operations will take place before the commencement of operations to ensure all tasks have been evaluated and proper engineering controls are employed. This evaluation will ensure employee exposures are below the 8-hour TWA PEL. If the 8-hour TWA is above 0.1 f/cc, then the sample will be analyzed by transmission electron microscopy (TEM) to identify the concentrations of asbestos structures.

Representative 30-minute short-term exposures will be determined for each task established during the initial operations evaluation. 30-minute excursions will be collected during periods that are most likely to produce the greatest exposure. The OSHA 30-minute excursion limit is 1.0 f/cc by PCM. If the 30-minute excursion limit is above 1.0 f/cc, then the sample will be analyzed by TEM to identify the concentrations of asbestos structures.

After 3 days of exposure monitoring per operation task, the data will be evaluated to determine if the level of respiratory protection should be modified. After 3 days of task based exposure monitoring, a sample collection frequency will be developed. The samples will be used to verify, continually confirm and document that the proper level of respiratory protection is in use for each landfill task.

5.1.4 Air Sample Collection and Analysis

Ambient air samples will be collected using a constant flow or critical orifice controlled sampling pump. Sampling pumps will be capable of providing the appropriate flow-rate and duration to achieve desired volumes. Personal breathing zone air samples will be collected using battery operated low volume sampling pumps. The personal air-sampling pump will be a self-contained unit small enough to be placed on the monitored employee and not interfere with the work performance. The pump must be capable of sampling at the desired flow-rate and duration.

Sampling pumps will be calibrated immediately before and after each sample period. Sampling pumps will be calibrated with the sampling cassette in-line using a primary calibrator or a rotometer calibrated to a primary calibrator. Rotometer calibration will be performed on a monthly basis during air sampling at the landfill.

Sampling cassettes will consist of a conductive filter holder consisting of a 25-mm diameter, 3-piece cassette having a 50-mm long electrically conductive extension cowl with a 25-mm cellulose backup pad. The filter membrane will consist of a mixed-cellulose ester (MCE), 25-mm, plain, white, 0.4 to 1.2-um pore size filter.

All personal and ambient air samples will be analyzed at the mobile laboratory in Libby, Montana. All personal breathing zone air samples will be analyzed using Phase Contrast Microscopy (PCM) in accordance with NIOSH Method 7400. The PCM laboratory results will be used to calculate the OSHA 8-hour TWA and the 30-minute excursion limit.

All ambient air samples and any personal breathing zone air samples that exceed the OSHA 8-hour TWA or 30-minute excursion limit by PCM analysis will be analyzed using transmission electron microscopy (TEM) in accordance with EPA Asbestos Hazard Emergency Response Act (AHERA) analytical methods (Appendix D).

TEM AHERA uses the same sampling procedures and counting rules as NIOSH Method 7400, but has the advantage over PCM of positive identification of asbestos. Raw analytical data is reported in total structures greater than or equal to 0.5 μm in length and separately for fibers greater than 5 μm in length. This method reports analytical results in total asbestos structures per square millimeter (S/mm^2) of the filter. Analysis of ambient air samples collected during landfill operations will be designed to maintain an analytical sensitivity of 0.005 structures per cubic centimeter (S/cc) of air based on the volume and effective filter area.

5.1.5 Quality Control Air Samples

Field personnel will prepare and collect three types of QC samples: lot blanks, field blanks, and replicate samples.

Lot Blanks

Lot blanks are prepared by submitting 2 unused air cassettes per 100 cassettes from the same lot for analyses to ensure the lot has not been contaminated. Lot blanks will be analyzed by both NIOSH 7400 and TEM AHERA before the lot of cassettes are used to collect air samples. If the lot is proved to be contaminated with 2 or more fibers per cc by PCM or 1 or more structures per mm² by TEM AHERA, then the lot of cassettes will be discarded and a new lot of cassettes will be obtained.

Field Blanks

Each sample group will include a minimum of two field blanks. Additional field blanks will be collected at a frequency of 10%. These blanks will come from the same lot as the filters used for the sample collection. The field blank results shall be averaged and subtracted from the analytical results before reporting. Any samples represented by a field blank having a result in excess of the detection limit shall be rejected. Field blanks will be collected by removing the cap from the sample cassette at the time of sampling for not more than 30 seconds and replacing it.

Replicate Samples

As a means of ensuring QC during ambient air sampling, field personnel will collect field replicate samples (co-located samples). Replicate samples will be collected at the same flow-rate, duration and using the same type of equipment used to collect the field samples. Field replicate samples will be collected at a rate of 1 per 20 samples (5%).

5.1.6 Sample Identification

Each personal air sample and ambient air sample will be identified with a unique coding system. For QC purposes, this coding system (Index ID) is designed to prevent accidental duplication of sample identification numbers and ensures that all samples have a unique identification number assigned to them. These codes start at XX-00001, which corresponds to the Landfill air sampling team. The last five numbers are sequential so thousands of unique codes are available, as necessary. To ensure that the laboratory is "blind" or unbiased, and does not receive certain specific information about a sample, only the index identification code will be used to label sample cassettes.

This coding system may be modified to suit field conditions and any modifications will be clearly described in the applicable field logbook.

5.1.7 Sample Documentation

Sampling activities will be documented in a field logbook and on field data sheets (Appendix E) to be maintained by the field team according to CDM Federal Programs

Corporation SOP 4-1 Field Logbook Content and Control (Appendix F). The field team leader will be responsible for maintenance and document control of the field logbook.

5.1.8 Sample Custody, Packaging, and Shipping

This section details the sample custody and the classifying, identifying, labeling, packaging, and transportation of ambient and personal air samples collected during landfill operations. Sample classification is necessary to ensure the protection of personnel involved in the shipment of samples, and to maintain the integrity of each sample. Personal air samples and ambient air samples collected during this assessment will be packaged and shipped according to CDM's SOP 2-1 Packaging and Shipping of Environmental Samples Revision 1, dated June 20, 2001 (Appendix F).

To maintain a record of sample collection, transfer between personnel, shipment, and receipt by the laboratory, chain-of-custody (COC) records will be used. The COC record will be maintained as physical evidence of sample custody and control and provides the means to identify, track, and monitor each individual sample from the point of collection through final data reporting. COC procedures will follow the requirements set forth in CDM SOP 1-2 Sample Custody, with approved project specific modifications (Appendix F).

The following modifications to SOP 1-2 have been reviewed and approved:

Section 5.2, Sample Labels and Tags - A label will be affixed to each air sampling cassette prior to being shipped to the appropriate laboratory. This number will correspond to the number assigned (XX, Index ID) to that particular sample in the field data sheets.

Samples collected during this investigation will be packaged and shipped according to CDM SOP 2-1 Packaging and Shipping of Environmental Samples (Appendix F).

The approved modifications to SOP 2-1 are as follows:

Section 4.0, Required Equipment - No vermiculite or other absorbent material will be used. No bubble wrap or ice will be used.

5.1.9 Equipment Decontamination

This project requires the decontamination of all personal air sampling and ambient air sampling equipment (e.g., pumps, cassettes, tubing, etc) prior to sampling and prior to leaving the site. Equipment used to collect, handle, or calibrate samples will be decontaminated.

The decontamination procedure for nondisposable equipment will consist of wet wiping the exposed surfaces. All equipment will then be allowed to air-dry. All equipment will be decontaminated before coming into contact with any sample.

5.2 Groundwater Monitoring

5.2.1 Field Investigation

One monitoring wells was installed up gradient (CDM-MW-7) and one monitoring well was installed down gradient (CDM-MW-8) of the Class IV Asbestos landfill. The locations of the monitoring wells are shown on Figure 5. Monitoring well construction diagrams are included in the Geotechnical Memorandum (Appendix B). The monitoring wells were advanced to 259 feet below ground surface (bgs) and 239 feet bgs, respectively. Previous investigative reports indicate that the regional aquifer is located a depth greater than 300 feet bgs while a perched aquifer was identified in the vicinity of the landfill at a depth of 150 to 200 feet bgs. Monitoring wells CDM-MW-7 and CMD-MW-8 were installed within the perched aquifer.

5.2.2 Groundwater Sampling

Monitoring wells CDM-MW-7 and CDM-MW-8 were sampled on July 30 and July 31, 2002 and analyzed for volatile organic compounds (VOCs), total petroleum hydrocarbons (diesel range organics and gasoline range organics), polychlorinated biphenyls (PCBs), priority pollutant 13 metals (PP13 metals), and polynuclear aromatic hydrocarbons (PAHs) by EnChem in Madison, Wisconsin, and asbestos by ESML in Libby, Montana. Prior to sampling, these newly installed monitoring wells were developed by bailing and pumping using a pumping truck equipped with a stainless steel submersible pump and bailer. Each well was purged for several hours until the turbidity was decreased and the purge water was visually clear. The tubing was decontaminated by running the exterior through a box steam cleaner. Alconox and water were pumped to decontaminate the interior of the hosing and the pump. Baseline sampling data for monitoring wells CDM-MW-7 and CDM-MW-8 is included as Appendix G. Each sample was assigned a unique sample identification number when submitted to the laboratory. The sample description (monitoring well ID) and corresponding sample ID numbers are listed below:

<u>Sample ID</u>	<u>Sample Description</u>
1R-14261	MW-8 groundwater sample
1R-14262	MW-8 duplicate groundwater sample
1R-14263	MW-7 groundwater sample

Monitoring wells CDM-MW-7 and CDM-MW-8 will be sampled in May of 2003, prior to commencement of ACM disposal in landfill Cell A. Future sampling of monitoring wells CDM-MW-7 and CDM-MW-8 will occur semi-annually in June and December during low and high groundwater periods and to coincide with Lincoln County's landfill monitoring well sampling schedule. Groundwater samples will be collected in accordance with CDM's SOPs: 1-6, Water Level Measurement; 4-3, Well Development and Purging; and 1-5, Groundwater Sampling Using Bailers (Appendix F). A submersible pump, Grundfos or equivalent, will be employed for purging and

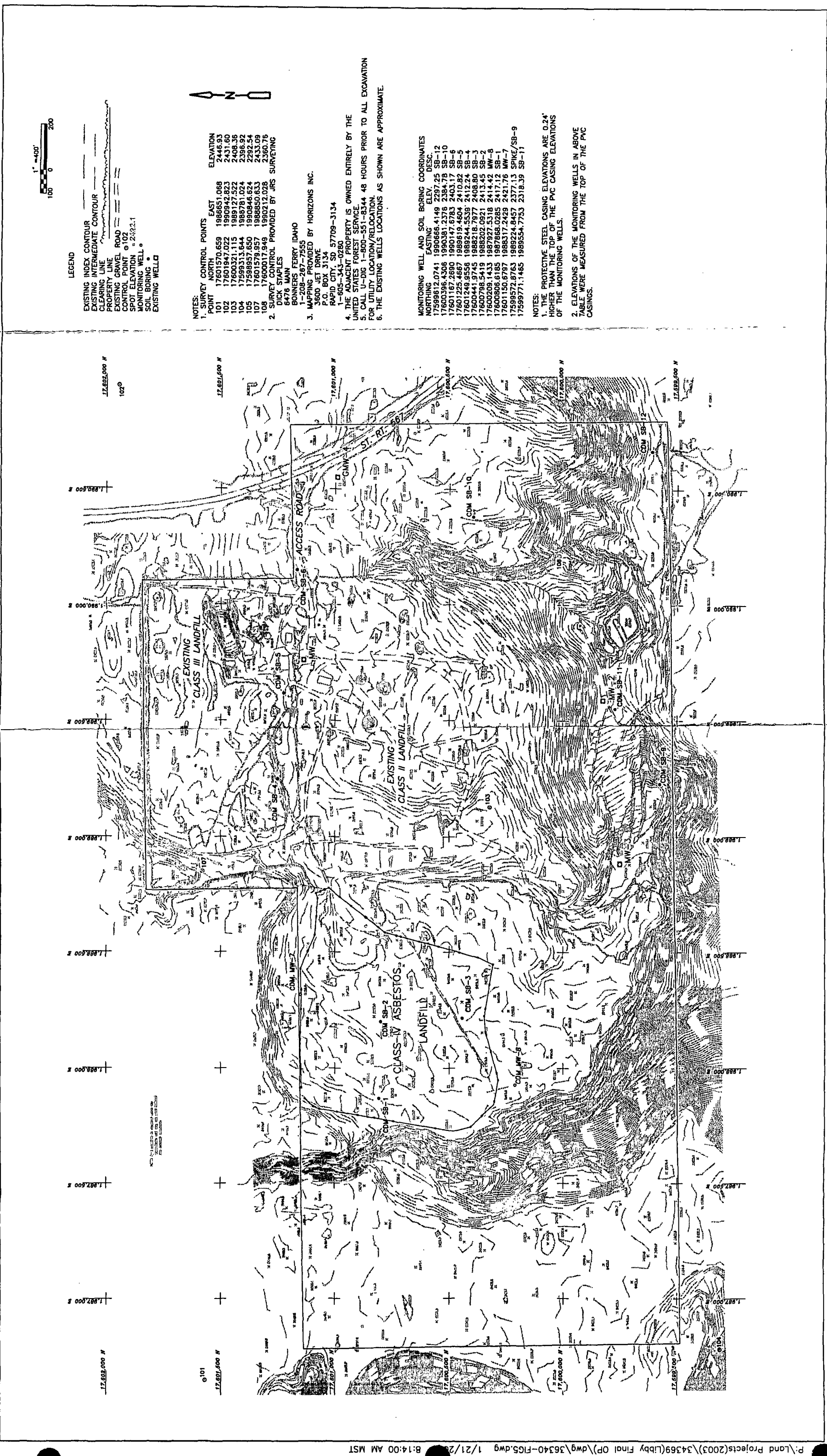


Figure No. 5
SOIL BORING AND MONITORING WELL LOCATIONS

sampling using low flow groundwater purging and sampling techniques. Prior to purging, water depth will be measured to the nearest 0.01 foot using a water level indicator. The monitoring wells will be purged at a rate of 100 to 500 millimeters per minute using either dedicated or disposable Teflon tubing. During purging, field parameters (temperature, dissolved oxygen, pH, specific conductance, and turbidity) will be measured and recorded. Purging will be considered complete when the field parameters stabilize within 10 percent for three consecutive readings or until three monitoring well pore volumes were purged. Purge water will be handled in accordance with SOP 2-2, Guide to Handling Investigation-Derived Waste (Appendix F).

Sampling activities will be documented in a field logbook and on field data sheets (Appendix E) to be maintained by the field team according to CDM SOP 4-1 Field Logbook Content and Control (Appendix F). The field team leader will be responsible for maintenance and document control of the field logbook.

Samples will be collected in laboratory-supplied bottles with appropriate preservative and placed in a chilled container immediately after sampling. Samples will be packaged and shipped to the appropriate laboratory in accordance with SOPs 1-2, Sample Custody and 2-1 Packaging and Shipping of Environmental Samples (Appendix F).

The submersible pump and any equipment not dedicated to a specific well will be decontaminated between monitoring wells in accordance with SOP 4-5, field Equipment Decontamination (Appendix F).

5.2.3 Sample Analysis

All samples will be analyzed for the parameters listed in Table 1 of ARM 17.50.708(16)(b). These parameters are includes in the table below:

Table 2 Ground Water Monitoring Parameters

Metals	Volatile Organic Compounds	Other
Antimony	Acetone	Chloride
Arsenic	Acrylonitrile	Nitrate (as N)
Barium	Benzene	Sulfate (SO ₄)
Beryllium	Bromochloromethane	Chemical Oxygen
Cadmium	Bromodichloromethane	Demand (COD)
Chromium	Bromoform	pH
Cobalt	Carbon disulfide	Specific
Copper	Carbon tetrachloride	conductance
Cyanide	Chlorobenzene	
Iron	Chloroethane	
Lead	Chloroform	
Mercury	Chlorodibromomethane	
Nickel	Dichlorodifluoromethane	
Selenium	1,2-Dibromo-3-chloropropane (DBCP)	
Silver	1,2-Dibromoethane(EDB)	
Thallium	o-Dichlorobenzene(1,2-Dichlorobenzene)	
Vanadium	p-Dichlorobenzene (1,4-Dichlorobenzene)	
Zinc	trans-1,4-Dichloro-2-butene	
	1,1-Dichloroethane	

Table 2 Ground Water Monitoring Parameters

Metals	Volatile Organic Compounds	Other
	1,2-Dichloroethane 1,1-Dichloroethylene cis-1,2-Dichloroethylene trans-1,2-Dichloroethylene 1,2-Dichloropropane cis-1,3-Dichloropropene trans-1,3-Dichloropropene Ethylbenzene 2-Hexanone(Methyl butyl ketone) Methyl bromide (Bromomethane) Methyl chloride(Chloromethane) Methylene bromide(Dibromomethane) Methylene chloride Methyl ethyl ketone (MEK) Methyl iodide (Iodomethane) 4-Methyl-2-pentanone(Methyl isobutyl ketone) Styrene 1,1,1,2-Tetrachloroethane 1,1,2,2-Tetrachloroethane Tetrachloroethylene Toluene 1,1,1-Trichloroethane 1,1,2-Trichloroethane Trichloroethene Trichlorofluoromethane 1,2,3-Trichloropropane Vinyl acetate Vinyl chloride Xylenes	

Groundwater samples will be submitted to EnChem for laboratory analysis under Chain of Custody protocol. The samples will be chilled and shipped via overnight carrier. Groundwater samples will also be analyzed for asbestos fibers by EMSL. The parameters listed in Table 1 and asbestos will be monitored in the groundwater twice per year. The Department of Environmental Quality (DEQ) may specify an alternative frequency and/or list of parameters for repeated sampling and analysis if it can be demonstrated that the removed constituents are not expected in or derived from the waste contained in the unit.

5.2.4 Quality Assurance/Quality Control

One groundwater field duplicate and one field blank will be collected during groundwater sampling activities and analyzed for the same parameters. A trip blank will accompany all shipments of samples to be analyzed for VOCs.

The laboratory shall meet or exceed the QA/QC requirements of the USEPA methods, including matrix spikes, matrix spike duplicates, surrogate spikes, method blanks, and detection limits. Upon receipt of the analytical results, the data will be validated according to CLP Guidelines, with data qualifiers assigned as needed.

Section 6

Construction Quality Assurance/Construction Quality Control Plan

The section summarizes the quality assurance and quality control (QA/QC) procedures to be followed during construction of the final cover system at the Lincoln County Class IV Asbestos Landfill. The purpose of these procedures is to evaluate and document that cover construction is in accordance with design specifications.

6.1 Construction Schedule/Inspection Frequency

Final cover and stormwater drainage ditches will be constructed after each of the four cells has been filled. The final cover construction phase for each cell should occur during nonwinter months to assure optimal material compaction conditions. During the construction phase, a qualified representative of the EPA on-scene coordinator, the CO, and/or the COTR will, at a minimum, collect a specific number of samples in order to certify that construction is in conformance with Montana rules (ARM 17.50.530(3)) and with construction specifications.

6.2 Final Cover

The final cover system will be constructed in accordance with ARM 17.50.530(3). The final cover system will have a total thickness of 24 inches and consist of a barrier layer and top vegetative layer. All cover material, with the exception of the uppermost 6 inches (topsoil), will be compacted in finished lifts of no greater than 6 inches parallel to the slope, to at least 95 percent of standard proctor maximum dry density, with moisture contents within 3 percent of the optimum moisture content. The thickness of the lifts prior to compaction will be determined from experience with the soil but in no case will they exceed 9 inches.

6.2.1 Barrier Layer

The barrier layer of the final cover will be placed and compacted to achieve a permeability of no greater than 1×10^{-5} cm/sec. Soil used for the barrier layer will be obtained from on-site borrow sources. Limited exploratory borings and laboratory testing was performed on the soils in these borrow sources. The limited testing indicated that borrow source soils will meet the required permeability. The geotechnical memorandum is provided as Appendix B.

The barrier layer for the final cover will be placed and compacted to achieve permeability satisfactory to the EPA on-scene coordinator, the CO, and/or the COTR and in accordance with Montana Refuse Disposal Rules. The minimum thickness of the barrier layer will be 18 inches. Quality control during construction of the barrier will be determined by the following testing program:

- Density testing of the waste barrier layer will occur at a frequency of at least five tests per lift per acre. The location of the tests will be documented. Testing will be in accordance with American Society for Testing and Materials (ASTM D2937 or D2992). Passing densities will meet or exceed 95 percent of standard densities.
- Soils used in Proctor tests will be characterized by the following: Atterberg Limits (ASTM D4318), grain size distribution (ASTM D422), and natural moisture (ASTM D2216). These tests will be performed at a minimum of two tests per acre per lift.
- Undisturbed permeability testing in accordance with ASTM D5084 at a frequency of one test per acre per lift.
- The thickness of the barrier layer will be checked by the engineer during and after construction using hand auger test probes or push tubes on a random grid interval to be determined by the EPA on-scene coordinator, the CO, and/or the COTR. The frequency shall be five tests per acre at a minimum.

Any holes in the barrier layer from test probes, core sampling, and compaction testing will be repaired with low-permeability material (bentonite, soil-bentonite mix, clay or other low permeability barrier layer soil) as instructed by the EPA on-scene coordinator/CO/COTR.

6.2.2 Test Pad Construction

A test pad shall be constructed on-site using the same material, equipment, processing and installation procedures that will be used during full-scale low permeability barrier layer cap construction. If approved by the EPA on-scene coordinator/CO/COTR, the test pad may be installed within the boundary layer limits and incorporated in the work, provided the pad passes all testing requirements. The dimensions of the test pad will be 40 feet wide by 60 feet long. The test pad will be constructed of the same material as described above. It will be built using the same loose lift thickness, type of compactor, weight of compactor, operating speed, and minimum number of passes that are proposed for the actual barrier layer.

The testing frequency for the test pad will be as follows:

- Density and moisture content testing of the test pad will occur at a frequency of at least three tests per lift. The location of the test will be documented. Testing will be in accordance with ASTM D1556. Passing densities will meet or exceed 95 percent of standard densities.
- One triaxial type hydraulic conductivity test (ASTM D5084) will be performed on each lift of the test pad per lift. These tests will be performed on 3-inch diameter undisturbed samples obtained from a Shelby tube (ASTM D1587) or drive cylinder per the specifications.

- The low permeability barrier layer thickness shall be determined from three density test locations per lift using a method consisting of hand augering or push tubes sampling (with a minimum of a 3/4" diameter sample).

6.2.3 Top Vegetative Layer

The top vegetative layer will be 6 inches thick. Topsoil will be obtained from on- site or off-site borrow areas. Testing of the topsoil will consist of the pH, organic content, percent cation exchange capacity (CEC), soil texture, and nutrient content for each borrow source. The results of the test will determine if amendments (lime, fertilizer, etc.) are necessary for vegetative growth. Immediately after construction of the topsoil layer and any surface water diversion structures, the final cover will be revegetated.

The final cover will be revegetated by the scarification of the top layer (minimum 2 inches) with drill seeding or hydroseeding. The seed mix will be as follows:

Table 3 Seed Mix

Plant Species			Seeding Rates (Pounds Pure Live Seed per Acre)	
Botanical Name	Common Name	Grass Composition (%)	Drill Seeding	Broadcast or Hydroseeding
Festuca ovina, var. Covar	sheep fescue	10	1.2	2.4
Bromus marginatus, var. Bromar	mountain brome	25	3.0	6.0
Phleum alpinum	alpine timothy	15	1.8	3.6
Thinopyrum intermedium	intermediate wheatgrass	5	0.6	1.2
Elymus lanceolatus	streambank wheatgrass	20	2.4	4.8
Elymus Canadensis	Canada wildrye	10	1.2	2.4
Elymus trachycaulus	slender wheatgrass	5	0.6	1.2
Pseudoroegneria spicata	bluebunch wheatgrass	10	1.2	2.4
Total Grasses		100	12	24
Astragalus cicer	Milkvetch	NA	1.5	3.0
Lotus corniculatus	birdsfoot trefoil	NA	1.5	3.0
Total Herbaceous Perennials		NA	15.0	30.0
Secale cereale	cereal rye	NA	3.0	6.0

Certified seeds should be used. Per State of Montana regulations, seed shall contain no prohibited noxious weed seed. Seed shall be certified weed-free by the seed supplier. The application of fertilizer should consist of 34 percent nitrogen, 52 percent phosphorus, and 60 percent potassium, spread at a rate of 150 pounds/acre.

Appendix A
Asbestos Waste Shipment Record Form

Asbestos Waste Shipment Record Form

§ 61.149 40 CFR Ch. 1 (7-1-00 Edition)

Generator	1. Work site name and mailing address		Owner's name	Owner's telephone number
	2. Operator's name and address			Operator's telephone number
	3. Waste disposal site (WDS) name, mailing address, and physical site location			WDS phone number
	4. Name and address of responsible agency			
	5. Description of materials		6. Containers No. Type	7. Total Quantity m ³ (yd ³)
	8. Special handling instructions and additional information			
	9. OPERATOR'S CERTIFICATION: I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in proper condition for transport by highway according to applicable international and government regulations.			
	Printed/typed name and title Address and telephone no.		Signature	Month /Day/ Year
Transporter	10. Transporter 1 (Acknowledgement of receipt of materials)			

	Printed/typed name and title Address and telephone no.	Signature	Month /Day /Year
	11. Transporter 2 (Acknowledgement of receipt of materials)		
	Printed/typed name and title Address and telephone no.	Signature	Month/ Day /Year
Disposal site	12. Discrepancy indication space		
	13. Waste disposal site owner or operator: Certification of receipt of asbestos materials covered by this manifest except as noted in item 12.		
	Printed/typed name & title	Signature	Month/ Day/ Year

Instructions

Waste Generator Section (Items 1-9)

1. Enter the name of the facility at which asbestos waste is generated and the address at which the facility is located. In the appropriate spaces, also enter the name of the owner of the facility and the owner's phone number.
2. If a demolition or renovation, enter the name and address of the company and authorized agent responsible for performing the asbestos removal. In the appropriate spaces, also enter the phone number of the operator.
3. Enter the name, address, and physical site location of the waste disposal site (WDS) that will be receiving the materials. In the appropriate spaces, also enter the phone number of the WDS. Enter "on-site" if the waste will be disposed of on the generator's property.
4. Provide the name and address of the local, state, or EPA regional office responsible for administering the asbestos NESHAP program.
5. Indicate the types of asbestos waste materials generated. If from a demolition or renovation, indicate the amount of asbestos that is
 - Friable asbestos material
 - Non-friable asbestos material

6. Enter the number of containers used to transport the asbestos materials listed in item 5. Also enter one of the following container codes used in transporting each type of asbestos material (specify any other type of container used if not listed below):
 - DM - Metal drums, barrels
 - DP - Plastic drums, barrels
 - BA - 6 mil plastic bags or wrapping
8. Enter the quantities of each type of asbestos material removed in units of cubic meters (cubic yards).
9. Use this space to indicate special transportation, treatment, storage or disposal or Bill of Lading information. If an alternate waste disposal site is designated, note it here. Emergency response telephone numbers or similar information may be included here.
10. The authorized agent of the waste generator must read and then sign and date this certification. The date is the date of receipt by transporter.

NOTE: The waste generator must retain a copy of this form.

Transporter Section (Items 10 & 11)

11. & 11. Enter name, address, and telephone number of each transporter used, if applicable. Print or type the full name and title of person accepting responsibility and acknowledging receipt of materials as listed on this waste shipment record for transport. Enter date of receipt and signature.

NOTE: The transporter must retain a copy of this form.

Disposal Site Section (Items 12 & 13)

12. The authorized representative of the WDS must not in this space any discrepancy between waste described on this manifest and waste actually received as well as any improperly enclosed or contained waste. Any rejected materials should be listed and destination of those materials provided. A site that converts asbestos-containing waste material to non-asbestos material is considered a WDS.
13. The signature (by hand) of the authorized WDS agent indicates acceptance and agreement with statements on this manifest except as noted in item 12. The date is the date of signature and receipt of shipment.

NOTE: The WDS must retain a completed copy of this form. The WDS must also send a completed copy to the operator listed in item 2.

Appendix B

Geotechnical Memorandum

Memorandum

To: Peter Borowiec

From: William Taylor *W. Taylor*

Date: August 27, 2002

Subject: Libby, Montana Class IV Landfill Geotechnical Design Report

CDM is pleased to provide you with our geotechnical report for the Libby, Montana, Class IV landfill. This report includes a review of existing site conditions, evaluation of geotechnical landfill design issues, and review of final cover (cap) construction requirements. A brief discussion of the geotechnical issues associated with the access road, scale facility, and equipment decontamination pad is also included.

Introduction

Camp Dresser & McKee (CDM) is currently providing design services to the Volpe National Transportation Systems Center (Volpe) for the Class IV landfill at the existing Lincoln County landfill site. The Class IV landfill is being constructed for the disposal of asbestos and asbestos contaminated materials (ACM) generated by asbestos abatement work currently in progress.

The previous Class IV landfill design includes a series of 13 unlined disposal trenches. Each trench is to be approximately 550-feet long and 18-feet deep, with 1:1 (H:V) sideslopes. The current plan is to excavate the cells one at a time and fill them with ACM by either placing the waste in the cell with an excavator or end dumping roll off boxes at the edge of the cell.

In addition to the cell construction, the project also includes construction of an approximate 4,300 linear-foot gravel access road, scale house, weigh scale, and equipment decontamination pad. Soils used for construction of the road will largely be generated by cut and fill operation associated with the grading of the road.

Purpose and Scope

The purpose of our studies was to review the available subsurface information at the landfill, conduct additional subsurface explorations and laboratory tests, perform a geotechnical analysis of the landfill geometry and final cover system, provide a geotechnical analysis of the proposed access roads, scale facility, and decontamination pad soils, evaluate the suitability of an onsite low permeability soil source as final cover material, and make recommendations

regarding any geotechnical considerations of the proposed design. Specifically, the work included the following:

- Review boring logs resulting from the subsurface investigation overseen by personnel from the CDM Helena, Montana office,
- Perform a slope stability analysis of the landfill sideslopes based on the proposed geometry and the results of the subsurface investigation,
- Perform geotechnical laboratory testing of undisturbed permeability samples taken at the proposed landfill cell excavation depth,
- Perform geotechnical laboratory testing of samples taken from the proposed low permeability soil borrow source,
- Provide recommendations for the placement and compaction of the low permeability barrier layer soils for construction of the final cap,
- Perform an analysis of the foundation soils at the proposed scale facility,
- Perform an analysis of the foundation soils at the proposed decontamination pad, and
- Perform an analysis of the proposed access road soils.

Subsurface Investigation

To further define the subsurface conditions at the locations of the proposed landfill cells, scale facility, and decontamination pad, eight test borings were drilled by O'Keefe Drilling Company of Butte, Montana. The explorations were drilled using a truck mounted hydraulic drilling rig. Groundwater monitoring wells were installed in the location of the two completed boreholes utilizing an air rotary drilling rig. An additional four borings were made in the proposed low permeability soil borrow area. A CDM representative marked the boring locations in the field and monitored the drilling. Final soil boring and monitoring well locations and elevations were surveyed by JRS Surveying on July 31, 2002.

Borings CDM-SB-1 through CDM-SB-6, CDM-MW-7 and CDM-MW-8, and CDM-SB-9 through CDM-SB-12 were drilled in July, 2002 using hollow stem auger drilling techniques. Sampling, using a 1-3/8 inch inside diameter split spoon sampler, was conducted at approximately 5 ft. depth intervals in each boring. Standard Penetration Testing (SPT) was conducted at each sample location and was performed in general accordance with test procedure ASTM D-1586 using a 140-pound hammer falling 30 inches to drive the sampler. The number of blows required to drive the sampler each 6-inch increment was recorded and the Standard Penetration Resistance (N-value) was determined as the sum of the blows over

the middle 12-inches of penetration. A CDM representative visually classified the samples recovered.

The boring locations are shown on Figure 1. Logs of the test borings prepared by CDM are attached in Appendix A.

The site is generally overlain by a layer of topsoil, 6 to 24 inches in thickness, underlain by medium dense to very dense sands, silts, and gravels. There is also varying amounts of clay present in certain areas. CDM performed index testing on select split spoon soil samples at the onsite CDM Jessberger geotechnical laboratory in Libby, Montana. Based on particle size analysis and Atterberg limits testing, the soils are classified under the USCS system as CL or ML. Geotechnical laboratory test results are included in Appendix B.

Groundwater was found approximately 220 feet below ground surface.

Interpretation of general subsurface conditions presented herein is based on soil and groundwater conditions observed at the test boring location. However, subsurface soil conditions may vary beyond the boring locations.

Groundwater levels measured within boreholes at the time of exploration are not necessarily equalized readings and may not represent actual groundwater conditions. In addition, groundwater levels change with time, season, temperature, construction activities in the area, as well as other factors. Groundwater conditions at the time of construction may be different than found in the explorations.

If subsurface soil or groundwater conditions are found to be different than assumed, recommendations contained in this report should be reevaluated by CDM and confirmed in writing.

Landfill Design Recommendations

The Class IV landfill is designed as an open trench, 18-feet-deep with 1:1 (H:V) sideslopes. The final cover system is essentially an at-grade cap with an approximately 1.5 - 2.5 percent slope consisting of an 18-inch-thick low permeability barrier layer overlain with six inches of topsoil. The low permeability barrier layer must have an as-compacted permeability of 1×10^{-5} cm/sec or less. The landfill design does not include a bottom liner system or a leachate collection system. The landfill is not adding any additional weight to the subgrade soils, thus, post-construction subgrade settlement is expected to be small. Some rebound and recompression of the subgrade may occur during construction. However, since no liner or leachate collection system is planned, these movements have no impact on the design. More settlement may occur within the waste itself depending on the nature and placement of the material. It is expected however, that much of this settlement will occur prior to final capping.

A borrow source investigation was included to collect bulk samples of proposed low permeability barrier layer soils and to test those samples for remolded permeability. Although there is no requirement for a landfill bottom liner system, the Montana Department of Environmental Quality (DEQ) did require undisturbed sample permeability testing of the soils that will form the base of the landfill cells.

Slope Stability Analysis

The landfill will be excavated in the upper stratum (upper 20 feet) of the site soils that generally consist of dry, cohesionless sands, silts, and gravels. CDM performed a slope stability analysis of the proposed landfill geometry and concluded that the proposed 1:1 sideslopes would not meet the minimum recommended factor of safety of 1.5 for static conditions. Based on the information available from the boring logs, the maximum recommended slope of the landfill sideslopes should not exceed 2.5:1 (H:V).

Landfill Foundation Soil Permeability

CDM collected three undisturbed samples of the landfill foundation soils for permeability testing. The samples were tested by SK Geotechnical of Billings, Montana in accordance with ASTM D5084. Permeability ranged from 2.1×10^{-6} to 9.4×10^{-4} cm/sec. Permeability test results are included in Appendix C.

Low Permeability Soil Borrow Source Investigation

CDM performed four borings (CDM-SB-9 through CDM-SB-12) in the proposed borrow source and collected composite samples of auger cuttings. The samples were tested by the CDM Jessberger Geotechnical Laboratory in Cambridge, Massachusetts to establish the moisture-density relationships under both standard (ASTM D698) and modified (ASTM D1557) Proctor effort. Following the moisture-density testing, six samples were tested for remolded permeability in accordance with ASTM D5084.

Three samples were remolded to moisture-density values based on standard effort and three samples were remolded to moisture-density values based on modified effort. The results of the permeability testing is summarized below in Table 1:

Table 1

Remolded Borrow Soils Permeability Test Summary

Sample Number	Compaction Effort	Dry Density (pcf)	Remolded Moisture Content (%)	Permeability (cm/sec)
1	95% Modified	106.9	16.9	2.3E-07

2	100% Modified	115.4	18.2	1.3E-07
3	95% Modified	109.6	19.9	7.4E-08
4	95% Standard	104.3	19.2	9.7E-08
5	100% Standard	109.3	19.3	7.8E-08
6	95% Standard	104.3	21.3	9.3E-08

Moisture-density and permeability test results are included in Appendix D.

Based on the laboratory test results discussed above, it appears that the proposed low permeability borrow soils will meet the project requirements of 1×10^{-5} cm/sec or less if compacted to at least 95% of standard Proctor maximum dry density. The soil should also be compacted to at least 1% wet of the optimum moisture content. It should be noted that this recommendation is based on a limited amount of laboratory testing. Confirmatory testing prior to construction of the cap and field testing of undisturbed samples from the compacted cap should be included in the project specifications.

Scale Facility and Decontamination Pad Foundation Recommendations

The scale facility includes a 25 by 10 foot, single story, pre-fabricated scale house resting on an at-grade concrete slab. The decontamination pad is a 1-foot-thick, slab-on-grade concrete pad. The weighing mechanism is set on a concrete slab, which is located approximately seven feet below ground surface. Based on the available information, the structures may be constructed on shallow foundations or slabs-on-grade bearing on the naturally deposited undisturbed soils at the site. A net allowable bearing pressure for the scale facility soils of 2 tons per square foot should be used. Foundation subgrade soils should be firm and dry. Excavated soils may be used as backfill material. Any foundation subgrade backfill soils should be compacted to at least 95% of modified Proctor maximum dry density.

Foundations and slabs which are exposed to freezing should bear at least 5 ft below grade or be underlain by crushed stone encased in filter fabric to a depth of 5 ft below grade to provide frost protection.

For purposes of design, a friction coefficient of 0.5 may be assumed on the bottom of all footings and slabs for purpose of resisting lateral loads.

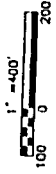
Access Road Recommendations

The access road design includes a gravel road constructed from cut and fill of the existing soils along the road alignment with a 2-inch-thick crushed gravel travel surface. A modified

Proctor test (ASTM D1557) was performed on a composite sample of material collected from two soil borings in the location of the proposed access roads by the CDM Jessberger Laboratory in Libby, Montana. Results of the modified Proctor test are included as Appendix E. Road subgrade soils in cut areas should be proofrolled with a fully loaded 10 wheel dump truck or other equipment of similar weight. Any areas that show excessive pumping, weaving, or rutting should be undercut and backfilled with suitable fill. Native soils may be used as backfill material. Road subgrade fill soils should be compacted to at least 95% of modified Proctor maximum dry density.

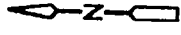
Limitations

This study was conducted according to generally accepted engineering practices. No other warranty, expressed or implied is made. If conditions encountered differ from those anticipated or there are any planned construction changes, the analysis and recommendations presented herein should be reevaluated and modified or confirmed in writing by CDM.



LEGEND

- EXISTING INDEX CONTOUR
- EXISTING INTERMEDIATE CONTOUR
- CLEARING LINE
- PROPERTY LINE
- EXISTING GRAVEL ROAD
- CONTROL POINT 102
- SPOT ELEVATION
- MONITORING WELL
- SOIL BORING



NOTES:

1. SURVEY CONTROL POINTS

POINT	NORTH	EAST	ELEVATION
101	17601570.559	1986551.068	2446.93
102	17601947.022	1986943.831	2431.50
103	17600321.115	1989127.522	2408.39
104	17599313.644	1988781.024	2389.52
105	17598957.650	1990846.824	2431.04
107	17601579.957	1988850.833	2431.04
108	1760017.949	1990212.028	2360.78

2. SURVEY CONTROL PROVIDED BY JRS SURVEYING

DICK STAPLES

6476 MAIN

BONNERS FERRY IDAHO

1-208-297-7555

3. MAPPING PROVIDED BY HORIZONS INC.

3600 JET DRIVE

P.O. BOX 3134

RAPID CITY, SD 57709-3134

1-605-343-0280

4. THE ADJACENT PROPERTY IS OWNED ENTIRELY BY THE UNITED STATES FOREST SERVICE.

5. CALL U-DIG 1-800-551-8344 48 HOURS PRIOR TO ALL EXCAVATION FOR UTILITY LOCATION/RELOCATION.

MONITORING WELL AND SOIL BORING COORDINATES

NORTHING	EASTING	ELEV.	DESC.
17599612.0741	1990666.4149	2297.25	SB-12
17600396.4306	1990381.2376	2384.78	SB-10
17601167.2690	1990147.6783	2403.17	SB-8
17601225.4667	1989619.4604	2410.82	SB-5
17601249.9558	1989244.5539	2412.24	SB-4
17600441.9745	1988218.7977	2408.80	SB-3
17600798.3419	1988202.0921	2413.45	SB-2
17600209.1433	1987927.5318	2414.42	NW-8
1760068.6185	1987468.0285	2417.12	SB-1
17601150.8797	1988317.2429	2421.76	NW-7
1759972.8763	1989224.8457	2377.13	SPIKE/SB-9
17599771.1465	1989554.7753	2318.39	SB-11

NOTE: THE MONITORING WELL STEEL CAP ELEVATION IS 0.24' HIGHER THAN THE TABLE ELEVATION.

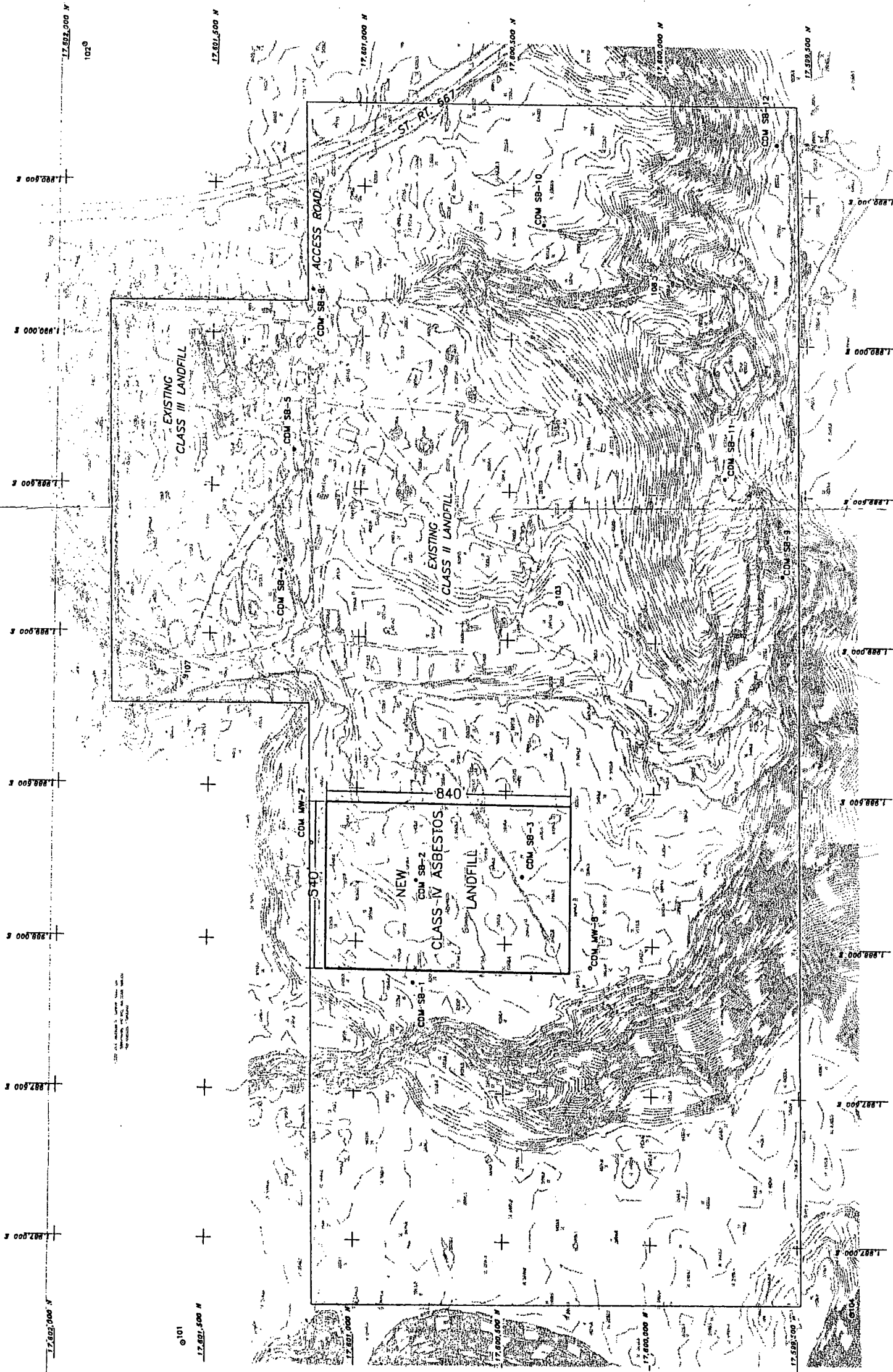


Figure No. 1
SOIL BORING AND MONITORING WELL LOCATIONS

TARGET SHEET
EPA REGION VIII
SUPERFUND DOCUMENT MANAGEMENT SYSTEM

DOCUMENT NUMBER: 2009648

SITE NAME: LIBBY ASBESTOS

DOCUMENT DATE: 04/01/2003

DOCUMENT NOT SCANNED

Due to one of the following reasons:

- ☐ PHOTOGRAPHS
- ☐ 3-DIMENSIONAL
- ☐ OVERSIZED
- ☐ AUDIO/VISUAL
- ☐ PERMANENTLY BOUND DOCUMENTS
- ☐ POOR LEGIBILITY
- ☐ OTHER
- ☐ NOT AVAILABLE
- ☒ TYPES OF DOCUMENTS NOT TO BE SCANNED
(Data Packages, Data Validation, Sampling Data, CBI, Chain of Custody)

DOCUMENT DESCRIPTION:

APPENDIX B

Appendix A Soil Boring and Monitoring Well Logs

Appendix B Geotechnical Laboratory Test Results Grain Size and
Atterberg Limits

TARGET SHEET
EPA REGION VIII
SUPERFUND DOCUMENT MANAGEMENT SYSTEM

DOCUMENT NUMBER: 2009648

SITE NAME: LIBBY ASBESTOS

DOCUMENT DATE: 04/01/2003

DOCUMENT NOT SCANNED

Due to one of the following reasons:

- ☐ PHOTOGRAPHS
- ☐ 3-DIMENSIONAL
- ☐ OVERSIZED
- ☐ AUDIO/VISUAL
- ☐ PERMANENTLY BOUND DOCUMENTS
- ☐ POOR LEGIBILITY
- ☐ OTHER
- ☐ NOT AVAILABLE
- ☒ TYPES OF DOCUMENTS NOT TO BE SCANNED
(Data Packages, Data Validation, Sampling Data, CBI, Chain of Custody)

DOCUMENT DESCRIPTION:

APPENDIX B

Appendix C Landfill Subgrade Permeability Test Results

Appendix D Low Permeability Soil Moisture-Density and Permeability
Test Results

Appendix E Access Road Modified Proctor Test Results

Appendix C

EPA SOP 2015 Asbestos Sampling



ASBESTOS SAMPLING

SOP#: 2015
DATE: 11/17/94
REV. #: 0.0

1.0 SCOPE AND APPLICATION

Asbestos has been used in many commercial products including building materials such as flooring tiles and sheet goods, paints and coatings, insulation, and roofing asphalts. These products and others may be found at hazardous waste sites hanging on overhead pipes, contained in drums, abandoned in piles, or as part of a structure. Asbestos tailing piles from mining operations can also be a source of ambient asbestos fibers. Asbestos is a known carcinogen and requires air sampling to assess airborne exposure to human health. This Standard Operating Procedure (SOP) provides procedures for asbestos air sampling by drawing a known volume of air through a mixed cellulose ester (MCE) filter. The filter is then sent to a laboratory for analysis. The U.S. Environmental Protection Agency/Environmental Response Team (U.S. EPA/ERT) uses one of four analytical methods for determining asbestos in air. These include: U.S. EPA's Environmental Asbestos Assessment Manual, Superfund Method for the Determination of Asbestos in Ambient Air for Transmission Electron Microscopy (TEM)⁽¹⁾; U.S. EPA's Modified Yamate Method for TEM⁽²⁾; National Institute for Occupational Safety and Health (NIOSH) Method 7402 (direct method only) for TEM; and NIOSH Method 7400 for Phase Contrast Microscopy (PCM)⁽³⁾. Each method has specific sampling and analytical requirements (i.e., sample volume and flow rate) for determining asbestos in air.

The U.S. EPA/ERT typically follows procedures outlined in the TEM methods for determining mineralogical types of asbestos in air and for distinguishing asbestos from non-asbestos minerals. The Phase Contrast Microscopy (PCM) method is used by U.S. EPA/ERT as a screening tool since it is less costly than TEM. PCM cannot distinguish asbestos from non-asbestos fibers, therefore the TEM method may be necessary to confirm analytical results. For example, if an action level for the presence of fibers has been set and PCM analysis indicates that the action level has been exceeded, then

TEM analysis can be used to quantify and identify asbestos structures through examination of their morphology crystal structures (through electron diffraction), and elemental composition (through energy dispersive X-ray analysis). In this instance samples should be collected for both analyses in side by side sampling trains (some laboratories are able to perform PCM and TEM analysis from the same filter). The Superfund method is designed specifically to provide results suitable for supporting risk assessments at Superfund sites, it is applicable to a wide range of ambient air situations at hazardous waste sites. U.S. EPA's Modified Yamate Method for TEM is also used for ambient air sampling due to high volume requirements. The PCM and TEM NIOSH analytical methods require lower sample volumes and are typically used indoors; however, ERT will increase the volume requirement for outdoor application.

Other Regulations pertaining to asbestos have been promulgated by U.S. EPA and OSHA. U.S. EPA's National Emission Standards for Hazardous Air Pollutants (NESHAP) regulates asbestos-containing waste materials. NESHAP establishes management practices and standards for the handling of asbestos and emissions from waste disposal operations (40 CFR Part 61, Subparts A and M). U.S. EPA's 40 CFR 763 (July 1, 1987)⁽⁴⁾ and its addendum 40 CFR 763 (October 30, 1987)⁽⁴⁾ provide comprehensive rules for the asbestos abatement industry. State and local regulations on these issues vary and may be more stringent than federal requirements. The OSHA regulations in 29 CFR 1910.1001 and 29 CFR 1926.58 specify work practices and safety equipment such as respiratory protection and protective clothing when handling asbestos. The OSHA standard for an 8-hour, time-weighted average (TWA) is 0.2 fibers/cubic centimeters of air. This standard pertains to fibers with a length-to-width ratio of 3 to 1 with a fiber length $>5 \mu\text{m}$ ^(5,6). An action level of 0.1 fiber/cc (one-half the OSHA standard) is the level U.S. EPA has established in which employers must initiate such activities as air monitoring, employee training, and

medical surveillance^(5,6).

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent upon site conditions, equipment limitations or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U.S. EPA endorsement or recommendation for use.

2.0 METHOD SUMMARY

Prior to sampling, the site should be characterized by identifying on-site as well as off-site sources of airborne asbestos. The array of sampling locations and the schedule for sample collection, is critical to the success of an investigation. Generally, sampling strategies to characterize a single point source are fairly straightforward, while multiple point sources and area sources increase the complexity of the sampling strategy. It is not within the scope of this SOP to provide a generic asbestos air sampling plan. Experience, objectives, and site characteristics will dictate the sampling strategy.

During a site investigation, sampling stations should be arranged to distinguish spatial trends in airborne asbestos concentrations. Sampling schedules should be fashioned to establish temporal trends. The sampling strategy typically requires that the concentration of asbestos at the source (worst case) or area of concern (downwind), crosswind, as well as background (upwind) contributions be quantified. See Table 1 (Appendix A) for U.S. EPA/ERT recommended sampling set up for ambient air. Indoor asbestos sampling requires a different type of strategy which is identified in Table 2 (Appendix A). It is important to establish background levels of contaminants in order to develop a reference point from which to evaluate the source data. Field blanks and lot blanks can be utilized to determine other sources.

Much information can be derived from each analytical method previously mentioned. Each analytical method has specific sampling requirements and produce results which may or may not be applicable to a specific sampling effort. The site sampling

objectives should be carefully identified so as to select the most appropriate analytical method. Additionally, some preparation (i.e., lot blanks results) prior to site sampling may be required, these requirements are specified in the analytical methods.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

3.1 Sample Preservation

No preservation is required for asbestos samples.

3.2 Sample Handling, Container and Storage Procedures

1. Place a sample label on the cassette indicating a unique sampling number. Do not put sampling cassettes in shirt or coat pockets as the filter can pick up fibers. The original cassette box is used to hold the samples.
2. Wrap the cassette individually in a plastic sample bag. Each bag should be marked indicating sample identification number, total volume, and date.
3. The wrapped sampling cassettes should be placed upright in a rigid container so that the cassette cap is on top and cassette base is on bottom. Use enough packing material to prevent jostling or damage. Do not use vermiculite as packing material for samples. If possible, hand carry to lab.
4. Provide appropriate documentation with samples (i.e., chain of custody and requested analytical methodology).

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Flow rates exceeding 16 liters/minute (L/min) which could result in filter destruction due to (a) failure of its physical support under force from the increased pressure drop; (b) leakage of air around the filter mount so that the filter is bypassed, or (c) damage to the asbestos structures due to increased impact velocities.

4.1 U.S. EPA's Superfund Method

4.1.1 Direct-transfer TEM Specimen Preparation Methods

Direct-Transfer TEM specimen preparation methods have the following significant interferences:

- C The achievable detection limit is restricted by the particulate density on the filter, which in turn is controlled by the sampled air volume and the total suspended particulate concentration in the atmosphere being sampled.
- C The precision of the result is dependent on the uniformity of the deposit of asbestos structures on the sample collection filter.
- C Air samples must be collected so that they have particulate and fiber loadings within narrow ranges. If too high a particulate loading occurs on the filter, it is not possible to prepare satisfactory TEM specimens by a direct-transfer method. If too high a fiber loading occurs on the filter, even if satisfactory TEM specimens can be prepared, accurate fiber counting will not be possible.

4.1.2 Indirect TEM Specimen Preparation Methods

Indirect TEM specimen preparation methods have the following interferences:

- C The size distribution of asbestos structures is modified.
- C There is increased opportunity for fiber loss or introduction of extraneous contamination.
- C When sample collection filters are ashed, any fiber contamination in the filter medium is concentrated on the TEM specimen grid.

It can be argued that direct methods yield an under-estimate of the asbestos structure concentration because many of the asbestos fibers present are concealed by other particulate material with which they are associated. Conversely, indirect methods can be considered to yield an over-estimate because some types of complex asbestos structures disintegrate

during the preparation, resulting in an increase in the numbers of structures counted.

4.2 U.S. EPA's Modified Yamate Method for TEM

High concentrations of background dust interfere with fiber identification.

4.3 NIOSH Method for TEM

Other amphibole particles that have aspect ratios greater than 3:1 and elemental compositions similar to the asbestos minerals may interfere in the TEM analysis. Some non-amphibole minerals may give electron diffraction patterns similar to amphiboles. High concentrations of background dust interfere with fiber identification.

4.4 NIOSH Method for PCM

PCM cannot distinguish asbestos from non-asbestos fibers; therefore, all particles meeting the counting criteria are counted as total asbestos fibers. Fiber less than 0.25 μm in length will not be detected by this method. High levels of non-fibrous dust particles may obscure fibers in the field of view and increase the detection limit.

5.0 EQUIPMENT/MATERIALS

5.1 Sampling Pump

The constant flow or critical orifice controlled sampling pump should be capable of a flow-rate and pumping time sufficient to achieve the desired volume of air sampled.

The lower flow personal sampling pumps generally provide a flow rate of 20 cubic centimeters/minute (cc/min) to 4 L/min. These pumps are usually battery powered. High flow pumps are utilized when flow rates between 2 L/min to 20 L/min are required. High flow pumps are used for short sampling periods so as to obtain the desired sample volume. High flow pumps usually run on AC power and can be plugged into a nearby outlet. If an outlet is not available then a generator should be obtained. The generator should be positioned downwind from the sampling pump. Additional voltage may be required if more than one pump is plugged into the same generator. Several

electrical extension cords may be required if sampling locations are remote.

The recommended volume for the Superfund method (Phase I) requires approximately 20 hours to collect. Such pumps typically draw 6 amps at full power so that 2 lead/acid batteries should provide sufficient power to collect a full sample. The use of line voltage, where available, eliminates the difficulties associated with transporting stored electrical energy.

A stand should be used to hold the filter cassette at the desired height for sampling and the filter cassette shall be isolated from the vibrations of the pump.

5.2 Filter Cassette

The cassettes are purchased with the required filters in position, or can be assembled in a laminar flow hood or clean area. When the filters are in position, a shrink cellulose band or adhesive tape should be applied to cassette joints to prevent air leakage.

5.2.1 TEM Cassette Requirements

Commercially available field monitors, comprising 25 mm diameter three-piece cassettes, with conductive extension cowls shall be used for sample collection. The cassette must be new and not previously used. The cassette shall be loaded with an MCE filter of pore size 0.45 μm , and supplied from a lot number which has been qualified as low background for asbestos determination. The cowls should be constructed of electrically conducting material to minimize electrostatic effects. The filter shall be backed by a 5 μm pore size MCE filter (Figure 1, Appendix B).

5.2.2 PCM Cassette Requirements

NIOSH Method 7400, PCM involves using a 0.8 to 1.2 μm mixed cellulose ester membrane, 25 mm diameter, 50 mm conductive cowl on cassette (Figure 2, Appendix B). Some labs are able to perform PCM and TEM analysis on the same filter; however, this should be discussed with the laboratory prior to sampling.

5.3 Other Equipment

- C Inert tubing with glass cyclone and hose barb
- C Whirlbags (plastic bags) for cassettes

- C Tools - small screw drivers
- C Container - to keep samples upright
- C Generator or electrical outlet (may not be required)
- C Extension cords (may not be required)
- C Multiple plug outlet
- C Sample labels
- C Air data sheets
- C Chain of Custody records

6.0 REAGENTS

Reagents are not required for the preservation of asbestos samples.

7.0 PROCEDURES

7.1 Air Volumes and Flow Rates

Sampling volumes are determined on the basis of how many fibers need to be collected for reliable measurements. Therefore, one must estimate how many airborne fibers may be in the sampling location.

Since the concentration of airborne aerosol contaminants will have some effect on the sample, the following is a suggested criteria to assist in selecting a flow rate based on real-time aerosol monitor (RAM) readings in milligrams/cubic meter (mg/m^3).

	<u>Concentration</u>	<u>Flow Rate</u>
C Low RAM readings:	<6.0 mg/m^3	11-15. L/min
C Medium RAM readings:	>6.0 mg/m^3	7.5 L/min
C High RAM readings:	>10. mg/m^3	2.5 L/min

In practice, pumps that are available for environmental sampling at remote locations operate under a maximum load of approximately 12 L/min.

7.1.1 U.S. EPA's Superfund Method

The Superfund Method incorporates an indirect preparation procedure to provide flexibility in the amount of deposit that can be tolerated on the sample filter and to allow for the selective concentration of asbestos prior to analysis. To minimize contributions to background contamination from asbestos present in the plastic matrices of membrane filters while allowing for sufficient quantities of asbestos to be collected, this method also requires the collection of a larger volume of air per unit area of filter than has traditionally been collected

for asbestos analysis. Due to the need to collect large volumes of air, higher sampling flow rates are recommended in this method than have generally been employed for asbestos sampling in the past. As an alternative, samples may be collected over longer time intervals. However, this restricts the flexibility required to allow samples to be collected while uniform meteorological conditions prevail.

The sampling rate and the period of sampling should be selected to yield as high a sampled volume as possible, which will minimize the influence of filter contamination. Wherever possible, a volume of 15 cubic meters (15,000 L) shall be sampled for those samples intended for analysis only by the indirect TEM preparation method (Phase 1 samples). For those samples to be prepared by both the indirect and the direct specimen preparation methods (Phase 2 samples), the volumes must be adjusted so as to provide a suitably-loaded filter for the direct TEM preparation method. One option is to collect filters at several loadings to bracket the estimated optimum loading for a particular site. Such filters can be screened in the laboratory so that only those filters closest to optimal loading are analyzed. It has been found that the volume cannot normally exceed 5 cubic meters (5000 L) in an urban or agricultural area, and 10 cubic meters (10,000 L) in a rural area for samples collected on a 25 mm filter and prepared by a direct-transfer technique.

An upper limit to the range of acceptable flow rates for this method is 15 L/min. At many locations, wind patterns exhibit strong diurnal variations. Therefore, intermittent sampling (sampling over a fixed time interval repeated over several days) may be necessary to accumulate 20 hours of sampling time over constant wind conditions. Other sampling objectives also may necessitate intermittent sampling. The objective is to design a sampling schedule so that samples are collected under uniform conditions throughout the sampling interval. This method provides for such options. Air volumes collected on Phase 1 samples are maximized (≤ 16 L/min). Air volumes collected on Phase 2 samples are limited to provide optimum loading for filters to be prepared by a direct-transfer procedure.

7.1.2 U.S. EPA's Modified Yamate Method for TEM

U.S. EPA's TEM method requires a minimum volume

of 560 L and a maximum volume of 3,800 L in order to obtain an analytical sensitivity of 0.005 structures/cc. The optimal volume for TEM is 1200 L to 1800 L. These volumes are determined using a 200 mesh EM grid opening with a 25-mm filter cassette. Changes in volume would be necessary if a 37-mm filter cassette is used since the effective area of a 25 mm (385 sq mm) and 37 mm (855 sq mm) differ.

7.1.3 NIOSH Method for TEM and PCM

The minimum recommended volume for TEM and PCM is 400 L at 0.1 fiber/cc. Sampling time is adjusted to obtain optimum fiber loading on the filter. A sampling rate of 1 to 4 L/min for eight hours (700 to 2800 L) is appropriate in non-dusty atmospheres containing 0.1 fiber/cc. Dusty atmospheres i.e., areas with high levels of asbestos, require smaller sample volumes (< 400 L) to obtain countable samples.

In such cases, take short, consecutive samples and average the results over the total collection time. For documenting episodic exposures, use high flow rates (7 to 16 L/min) over shorter sampling times. In relatively clean atmospheres where targeted fiber concentrations are much less than 0.1 fiber/cc, use larger sample volumes (3,000 to 10,000 L) to achieve quantifiable loadings. Take care, however, not to overload the filter with background dust. If $> 50\%$ of the filter surface is covered with particles, the filter may be too overloaded to count and will bias the measured fiber concentration. Do not exceed 0.5 mg total dust loading on the filter.

7.2 Calibration Procedures

In order to determine if a sampling pump is measuring the flow rate or volume of air correctly, it is necessary to calibrate the instrument. Sampling pumps should be calibrated immediately before and after each use. Preliminary calibration should be conducted using a primary calibrator such as a soap bubble type calibrator, (e.g., a Buck Calibrator, Gilibrator, or equivalent primary calibrator) with a representative filter cassette installed between the pump and the calibrator. The representative sampling cassette can be reused for calibrating other pumps that will be used for asbestos sampling. The same cassette lot used for sampling should also be used for the calibration. A sticker should be affixed to the outside of the extension cowl marked "Calibration Cassette."

A rotameter can be used provided it has been recently precalibrated with a primary calibrator. Three separate constant flow calibration readings should be obtained both before sampling and after sampling. Should the flow rate change by more than 5% during the sampling period, the average of the pre- and post-calibration rates will be used to calculate the total sample volume. The sampling pump used shall provide a non-fluctuating air-flow through the filter, and shall maintain the initial volume flow-rate to within $\pm 10\%$ throughout the sampling period. The mean value of these flow-rate measurements shall be used to calculate the total air volume sampled. A constant flow or critical orifice controlled pump meets these requirements. If at any time the measurement indicates that the flow-rate has decreased by more than 30%, the sampling shall be terminated. Flexible tubing is used to connect the filter cassette to the sampling pump. Sampling pumps can be calibrated prior to coming on-site so that time is saved when performing on-site calibration.

7.2.1 Calibrating a Personal Sampling Pump with an Electronic Calibrator

1. See Manufacturer's manual for operational instructions.
2. Set up the calibration train as shown in (Figure 3, Appendix B) using a sampling pump, electronic calibrator, and a representative filter cassette. The same lot sampling cassette used for sampling should also be used for calibrating.
3. To set up the calibration train, attach one end of the PVC tubing (approx. 2 foot) to the cassette base; attach the other end of the tubing to the inlet plug on the pump. Another piece of tubing is attached from the cassette cap to the electronic calibrator.
4. Turn the electronic calibrator and sampling pump on. Create a bubble at the bottom of the flow chamber by pressing the bubble initiate button. The bubble should rise to the top of the flow chamber. After the bubble runs its course, the flow rate is shown on the LED display.
5. Turn the flow adjust screw or knob on the pump until the desired flow rate is attained.

6. Perform the calibration three times until the desired flow rate of $\pm 5\%$ is attained.

7.2.2 Calibrating a Rotameter with an Electronic Calibrator

1. See manufacturer's manual for operational instructions.
2. Set up the calibration train as shown in (Figure 4, Appendix B) using a sampling pump, rotameter, and electronic calibrator.
3. Assemble the base of the flow meter with the screw provided and tighten in place. The flow meter should be mounted within 6° vertical.
4. Turn the electronic calibrator and sampling pump on.
5. Create a bubble at the bottom of the flow chamber by pressing the bubble initiate button. The bubble should rise to the top of the flow chamber. After the bubble runs its course, the flow rate is shown on the LED display.
6. Turn the flow adjust screw or knob on the pump until the desired flow rate is attained.
7. Record the electronic calibrator flow rate reading and the corresponding rotameter reading. Indicate these values on the rotameter (sticker). The rotameter should be able to work within the desired flow range. Readings can also be calibrated for 10 cm³ increments for Low Flow rotameters, 500 cm³ increments for medium flow rotameters and 1 liter increments for high flow rotameters.
8. Perform the calibration three times until the desired flow rate of $\pm 5\%$ is attained. Once on site, a secondary calibrator, i.e., rotameter may be used to calibrate sampling pumps.

7.2.3 Calibrating a Personal Sampling Pump with a Rotameter

1. See manufacturer's manual for Rotameter's Operational Instructions.

2. Set up the calibration train as shown in (Figure 5, Appendix B) using a rotameter, sampling pump, and a representative sampling cassette.
3. To set up the calibration train, attach one end of the PVC tubing (approx. 2 ft) to the cassette base; attach the other end of the tubing to the inlet plug on the pump. Another piece of tubing is attached from the cassette cap to the rotameter.
4. Assemble the base of the flow meter with the screw provided and tighten in place. The flow meter should be mounted within 6° vertical.
5. Turn the sampling pump on.
6. Turn the flow adjust screw (or knob) on the personal sampling pump until the float ball on the rotameter is lined up with the precalibrated flow rate value. A sticker on the rotameter should indicate this value.
7. A verification of calibration is generally performed on-site in the clean zone immediately prior to the sampling.

7.3. Meteorology

It is recommended that a meteorological station be established. If possible, sample after two to three days of dry weather and when the wind conditions are at 10 mph or greater. Record wind speed, wind direction, temperature, and pressure in a field logbook. Wind direction is particularly important when monitoring for asbestos downwind from a fixed source.

7.4 Ambient Sampling Procedures

7.4.1 Pre-site Sampling Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies needed.
2. Obtain necessary sampling equipment and ensure it is in working order and fully charged (if necessary).

3. Perform a general site survey prior to site entry in accordance with the site specific Health and Safety plan.
4. Once on-site the calibration is performed in the clean zone. The calibration procedures are listed in Section 7.2.
5. After calibrating the sampling pump, mobilize to the sampling location.

7.4.2 Site Sampling

1. To set up the sampling train, attach the air intake hose to the cassette base. Remove the cassette cap (Figure 6 and 7, Appendix B). The cassette should be positioned downward, perpendicular to the wind.
2. If AC or DC electricity is required then turn it on. If used, the generator should be placed 10 ft. downwind from the sampling pump.
3. Record the following in a field logbook: date, time, location, sample identification number, pump number, flow rate, and cumulative time.
4. Turn the pump on. Should intermittent sampling be required, sampling filters must be covered between active periods of sampling. To cover the sample filter: turn the cassette to face upward, place the cassette cap on the cassette, remove the inlet plug from the cassette cap, attach a rotameter to the inlet opening of the cassette cap to measure the flow rate, turn off the sampling pump, place the inlet plug into the inlet opening on the cassette cap. To resume sampling: remove the inlet plug, turn on the sampling pump, attach a rotameter to measure the flow rate, remove the cassette cap, replace the inlet plug in the cassette cap and invert the cassette, face downward and perpendicular to the wind.
5. Check the pump at sampling midpoint if sampling is longer than 4 hours. The generators may need to be regassed depending on tank size. If a filter darkens in appearance or if loose dust is seen in the filter, a second sample should be started.

6. At the end of the sampling period, orient the cassette up, turn the pump off.
7. Check the flow rate as shown in Section 7.2.3. When sampling open-faced, the sampling cap should be replaced before post calibrating. Use the same cassette used for sampling for post calibration (increase dust/fiber loading may have altered the flow rate).
8. Record the post flow rate.
9. Record the cumulative time or run.
10. Remove the tubing from the sampling cassette. Still holding the cassette upright, replace the inlet plug on the cassette cap and the outlet plug on the cassette base.

7.4.3. Post Site Sampling

1. Follow handling procedures in Section 3.2, steps 1-4.
2. Obtain an electronic or hard copy of meteorological data which occurred during the sampling event. Record weather: wind speed, ambient temperature, wind direction, and precipitation. Obtaining weather data several days prior to the sampling event can also be useful.

7.5 Indoor Sampling Procedures

PCM analysis is used for indoor air samples. When analysis shows total fiber count above the OSHA action level 0.1 f/cc then TEM (U.S. EPA's Modified Yamate Method) is used to identify asbestos from non-asbestos fibers.

Sampling pumps should be placed four to five feet above ground level away from obstructions that may influence air flow. The pump can be placed on a table or counter. Refer to Table 2 (Appendix A) for a summary of indoor sampling locations and rationale for selection.

Indoor sampling utilizes high flow rates to increased sample volumes (2000 L for PCM and 2800 to 4200 L for TEM) in order to obtain lower detection limits below the standard, (i.e., 0.01 f/cc or lower [PCM]

and 0.005 structures/cc or lower [TEM]).

7.5.1 Aggressive Sampling Procedures

Sampling equipment at fixed locations may fail to detect the presence of asbestos fibers. Due to limited air movement, many fibers may settle out of the air onto the floor and other surfaces and may not be captured on the filter. In the past, an 8-hour sampling period was recommended to cover various air circulation conditions. A quicker and more effective way to capture asbestos fibers is to circulate the air artificially so that the fibers remain airborne during sampling. The results from this sampling option typifies worst case condition. This is referred to as aggressive air sampling for asbestos. Refer to Table 2 for sample station locations.

1. Before starting the sampling pumps, direct forced air (such as a 1-horsepower leaf blower or large fan) against walls, ceilings, floors, ledges, and other surfaces in the room to initially dislodge fibers from surfaces. This should take at least 5 minutes per 1000 sq. ft. of floor.
2. Place a 20-inch fan in the center of the room. (Use one fan per 10,000 cubic feet of room space.) Place the fan on slow speed and point it toward the ceiling.
3. Follow procedures in Section 7.4.1 and 7.4.2 (Turn off the pump and then the fan(s) when sampling is complete.).
4. Follow handling procedures in Section 3.2, steps 1-4.

8.0 CALCULATIONS

The sample volume is calculated from the average flow rate of the pump multiplied by the number of minutes the pump was running (volume = flow rate X time in minutes). The sample volume should be submitted to the laboratory and identified on the chain of custody for each sample (zero for lot, field and trip blanks).

The concentration result is calculated using the sample volume and the numbers of asbestos structures reported after the application of the cluster and matrix counting criteria.

9.0 QUALITY ASSURANCE/ QUALITY CONTROL

Follow all QA/QC requirements from the laboratories as well as the analytical methods.

9.1 TEM Requirements

1. Examine lot blanks to determine the background asbestos structure concentration.
2. Examine field blanks to determine whether there is contamination by extraneous asbestos structures during specimen preparation.
3. Examine of laboratory blanks to determine if contamination is being introduced during critical phases of the laboratory program.
4. To determine if the laboratory can satisfactorily analyze samples of known asbestos structure concentrations, reference filters shall be examined. Reference filters should be maintained as part of the laboratory's Quality Assurance program.
5. To minimize subjective effects, some specimens should be recounted by a different microscopist.
6. Asbestos laboratories shall be accredited by the National Voluntary Laboratory Accreditation Program.
7. At this time, performance evaluation samples for asbestos in air are not available for Removal Program Activities.

9.2 PCM Requirements

1. Examine reference slides of known concentration to determine the analyst's ability to satisfactorily count fibers. Reference slides should be maintained as part of the laboratory's quality assurance program.
2. Examine field blanks to determine if there is contamination by extraneous structures during sample handling.

3. Some samples should be relabeled then submitted for counting by the same analyst to determine possible bias by the analyst.
4. Participation in a proficiency testing program such as the AIHA-NIOSH proficiency analytical testing (PAT) program.

10.0 DATA VALIDATION

Results of quality control samples will be evaluated for contamination. This information will be utilized to qualify the environmental sample results accordingly with the project's data quality objectives.

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA, and corporate health and safety procedures. More specifically, when entering an unknown situation involving asbestos, a powered air purifying respirator (PAPR) (full face-piece) is necessary in conjunction with HEPA filter cartridges. See applicable regulations for action level, PEL, TLV, etc. If previous sampling indicates asbestos concentrations are below personal health and safety levels, then Level D personal protection is adequate.

12.0 REFERENCES

- (1) Environmental Asbestos Assessment Manual, Superfund Method for the Determination of Asbestos in Ambient Air, Part 1: Method, EPA/540/2-90/005a, May 1990, and Part 2: Technical Background Document, EPA/540/2-90/005b, May 1990.
- (2) Methodology for the Measurement of Airborne Asbestos by Electron Microscopy, EPA's Report No. 68-02-3266, 1984, G. Yamate, S.C. Agarwal, and R. D. Gibbons.
- (3) National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Method. Third Edition. 1987.
- (4) U.S. Environmental Protection Agency. Code of Federal Regulations 40 CFR 763. July 1, 1987. Code of Federal Regulations 40 CFR 763 Addendum. October 30, 1987.

(5) U.S. Environmental Protection Agency.
Asbestos-Containing Materials in Schools;
Final Rule and Notice. 52 FR 41826.

(6) Occupational Safety and Health
Administration. Code of Federal Regulations
29 CFR 1910.1001. Washington, D.C.
1987.

APPENDIX A

Tables

TABLE 1. SAMPLE STATIONS FOR OUTDOOR SAMPLING		
Sample Station Location	Sample Numbers	Rationale
Upwind/Background ⁽¹⁾	Collect a minimum of two simultaneous upwind/background samples 30° apart from the prevailing windlines.	Establishes background fiber levels.
Downwind	Deploy a minimum of 3 sampling stations in a 180 degree arc downwind from the source.	Indicates if asbestos is leaving the site.
Site Representative and/or Worst Case	Obtain one site representative sample which shows average condition on-site or obtain worst case sample (optional).	Verify and continually confirm and document selection of proper levels of worker protection.

⁽¹⁾ More than one background station may be required if the asbestos originates from different sources.

APPENDIX A (Cont'd)

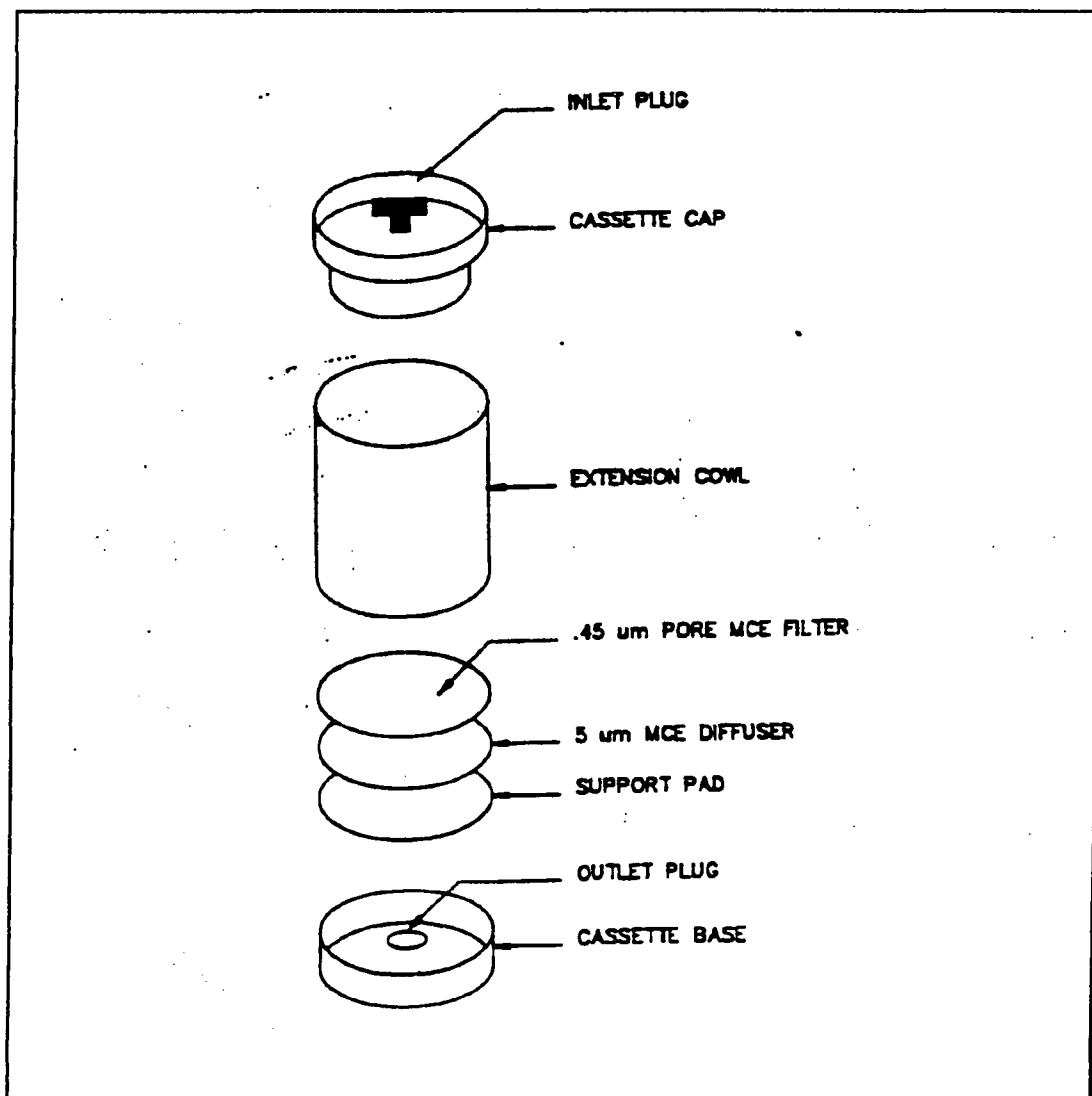
Tables

<p style="text-align: center;">TABLE 2</p> <p style="text-align: center;">SAMPLE STATIONS FOR INDOOR SAMPLING</p>		
Sample Station Location	Sample Numbers	Rationale
Indoor Sampling	<p>If a work site is a single room, disperse 5 samplers throughout the room.</p> <p>If the work site contains up to 5 rooms, place at least one sampler in each room.</p> <p>If the work site contains more than 5 rooms, select a representative sample of the rooms.</p>	Establishes representative samples from a homogeneous area.
Upwind/Background	If outside sources are suspected, deploy a minimum of two simultaneous upwind/background samples 30° apart from the prevailing windlines.	Establish whether indoor asbestos concentrations are coming from an outside source.
Worst Case	Obtain one worst case sample, i.e., aggressive sampling (optional).	Verify and continually confirm and document selection of proper levels of worker protection.

APPENDIX B

Figures

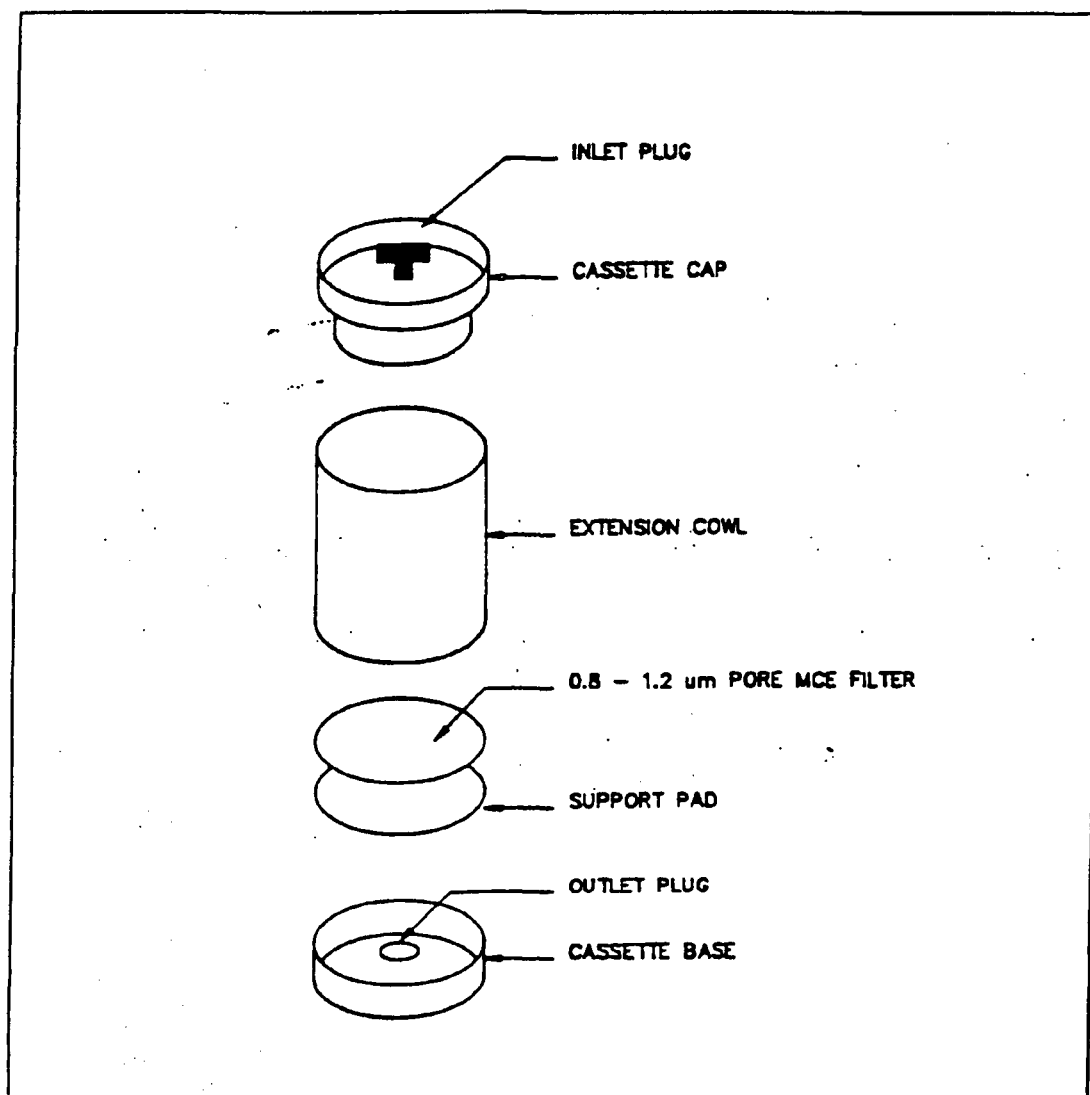
FIGURE 1. Transmission Electron Microscopy Filter Cassette



APPENDIX B (Cont'd)

Figures

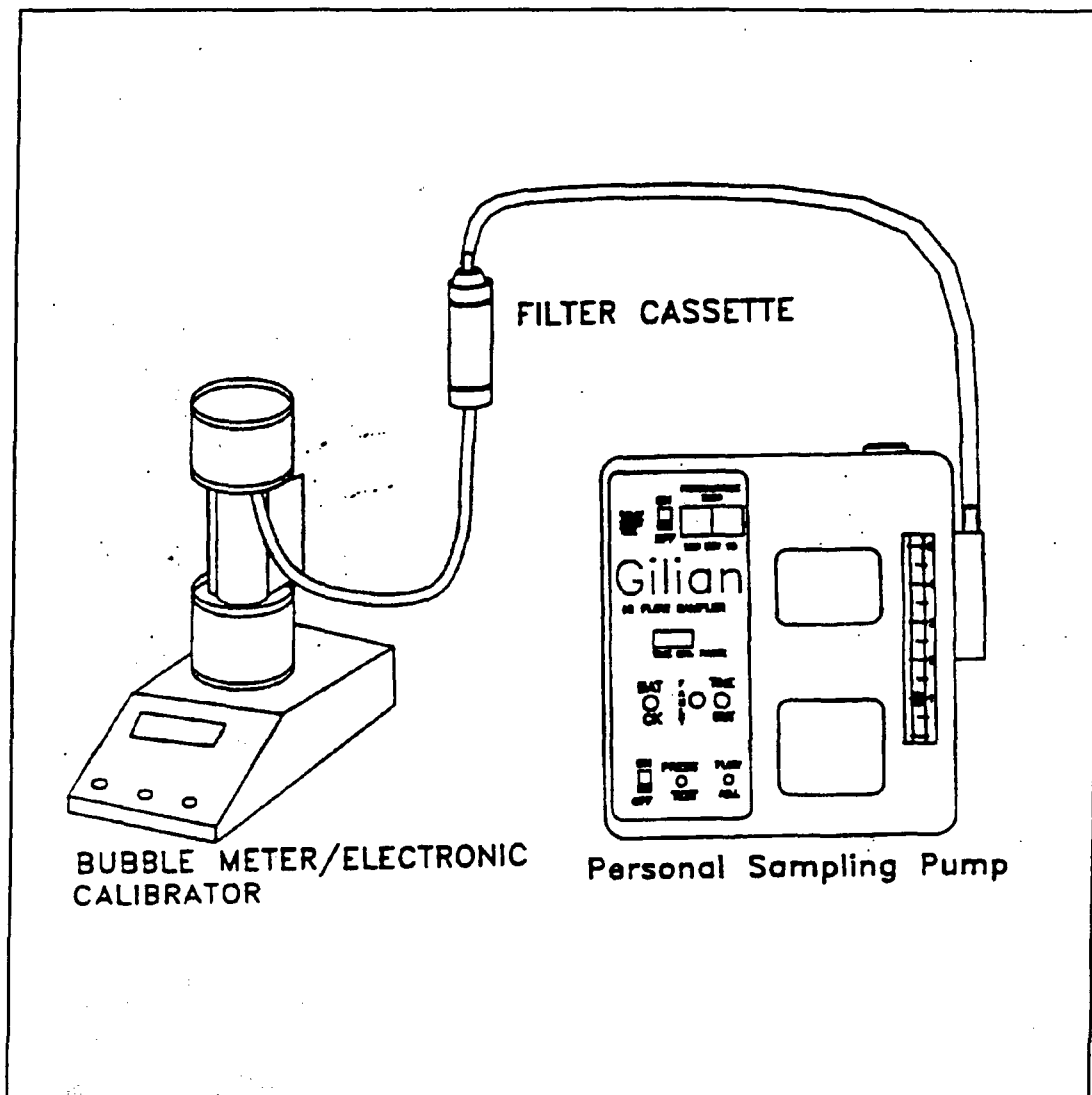
FIGURE 2. Phase Contrast Microscopy Filter Cassette



APPENDIX B (Cont'd)

Figures

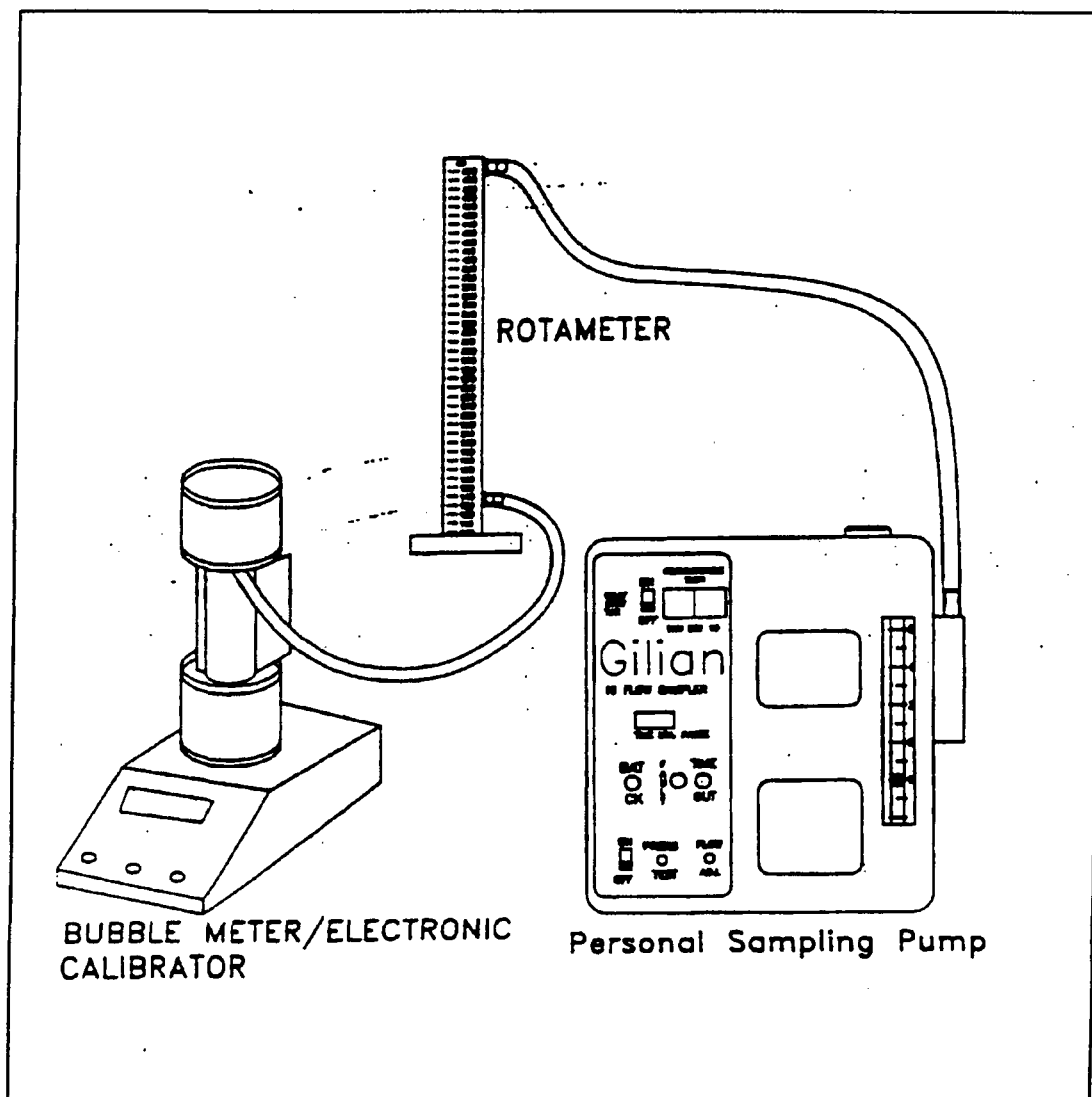
FIGURE 3. Calibrating a Personal Sampling Pump with a Bubble Meter



APPENDIX B (Cont'd)

Figures

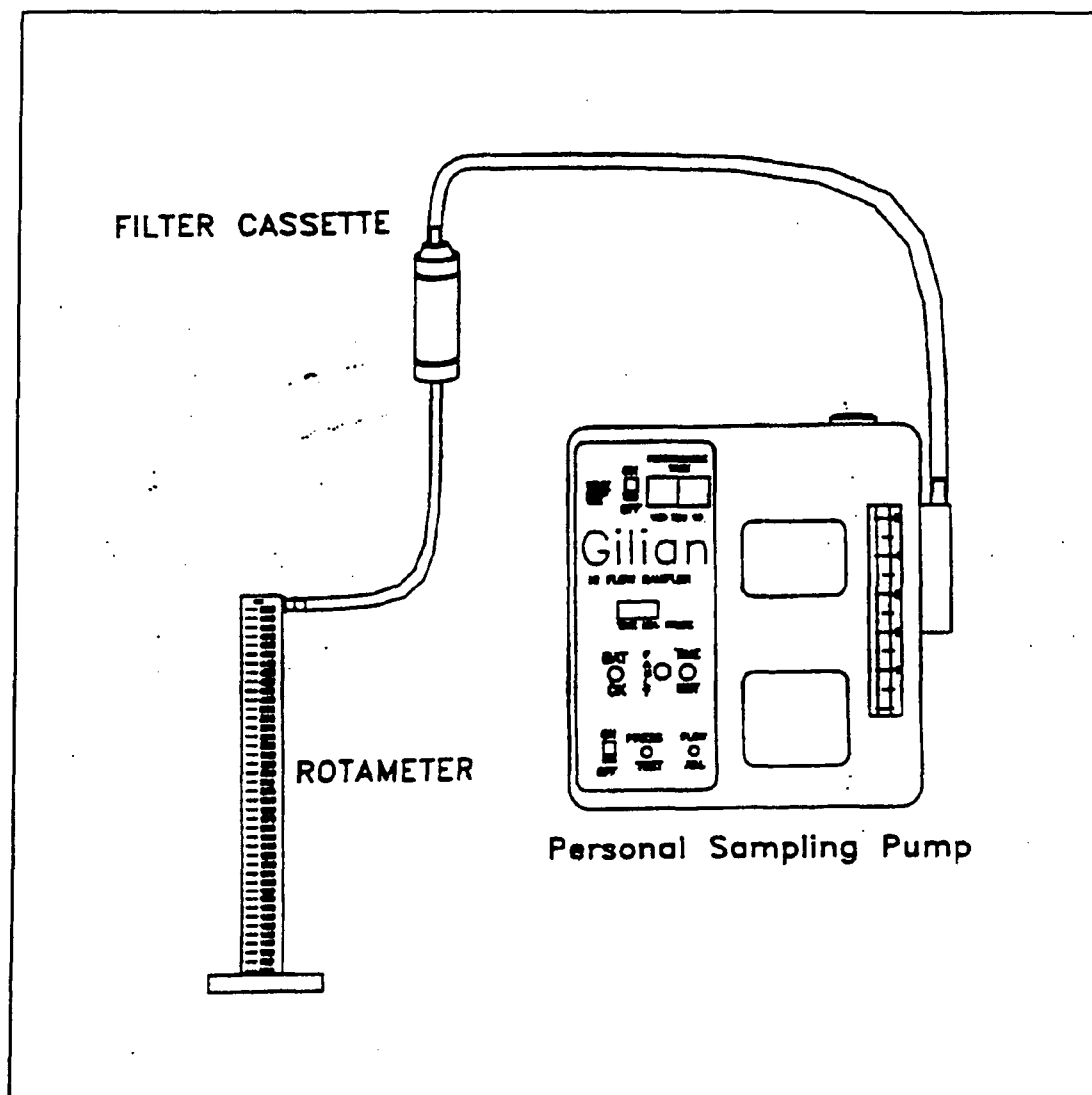
FIGURE 4. Calibrating a Rotameter with a Bubble Meter



APPENDIX B (Cont'd)

Figures

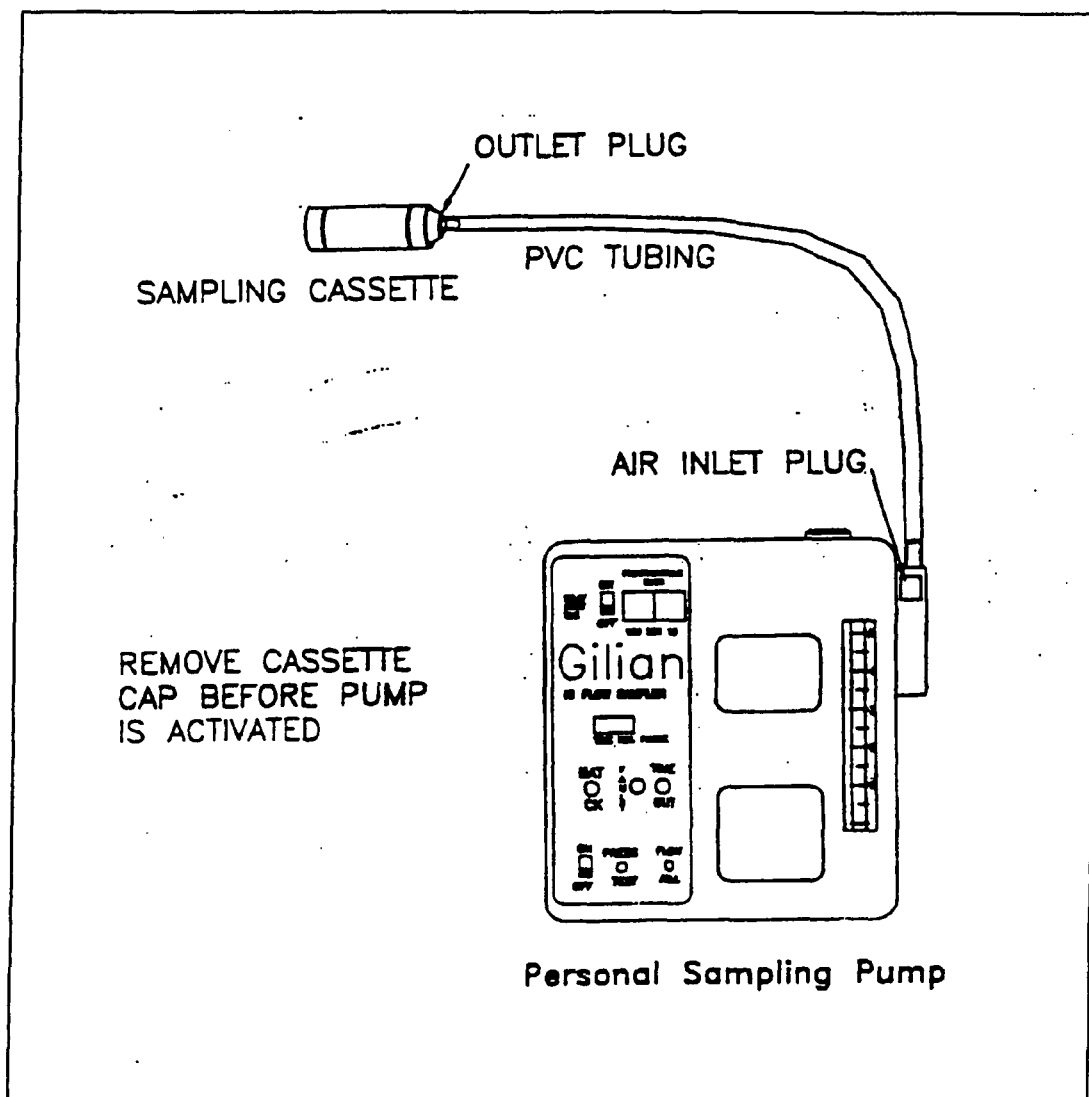
FIGURE 5. Calibrating a Sampling Pump with a Rotameter



APPENDIX B (Cont'd)

Figures

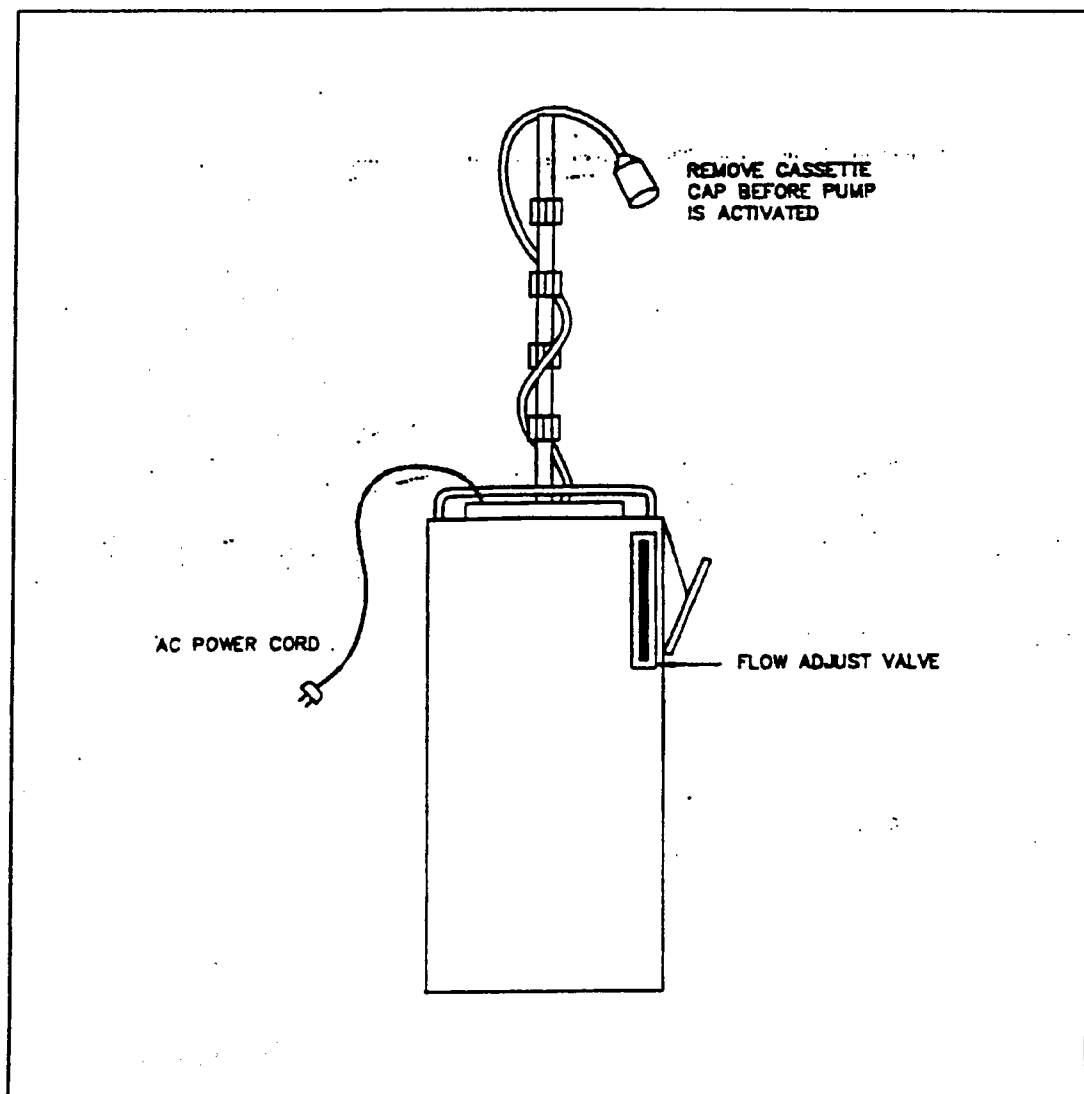
FIGURE 6. Personal Sampling Train for Asbestos



APPENDIX B (Cont'd)

Figures

FIGURE 7. High Flow Sampling Train for Asbestos



Appendix D
EPA Asbestos Hazard Emergency Response Act
(AHERA) Analytical Methods

Electronic Code of Federal Regulations

e-CFR

TM

THIS DATA CURRENT AS OF THE FEDERAL REGISTER DATED JANUARY 16, 2003

40 CFR - CHAPTER I - PART 763

View Part**Appendix A to Subpart E of Part 763 -- Interim Transmission Electron Microscopy Analytical Methods -- Mandatory and Nonmandatory -- and Mandatory Section to Determine Completion of Response Actions****I. Introduction**

The following appendix contains three units. The first unit is the mandatory transmission electron microscopy (TEM) method which all laboratories must follow; it is the minimum requirement for analysis of air samples for asbestos by TEM. The mandatory method contains the essential elements of the TEM method. The second unit contains the complete non-mandatory method. The non-mandatory method supplements the mandatory method by including additional steps to improve the analysis. EPA recommends that the non-mandatory method be employed for analyzing air filters; however, the laboratory may choose to employ the mandatory method. The non-mandatory method contains the same minimum requirements as are outlined in the mandatory method. Hence, laboratories may choose either of the two methods for analyzing air samples by TEM.

The final unit of this Appendix A to subpart E defines the steps which must be taken to determine completion of response actions. This unit is mandatory.

II. Mandatory Transmission Electron Microscopy Method**A. Definitions of Terms**

1. *Analytical sensitivity* -- Airborne asbestos concentration represented by each fiber counted under the electron microscope. It is determined by the air volume collected and the proportion of the filter examined. This method requires that the analytical sensitivity be no greater than 0.005 structures/cm³.
2. *Asbestiform* -- A specific type of mineral fibrosity in which the fibers and fibrils possess high tensile strength and flexibility.
3. *Aspect ratio* -- A ratio of the length to the width of a particle. Minimum aspect ratio as defined by

this method is equal to or greater than 5:1.

4. *Bundle* -- A structure composed of three or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.

5. *Clean area* -- A controlled environment which is maintained and monitored to assure a low probability of asbestos contamination to materials in that space. Clean areas used in this method have HEPA filtered air under positive pressure and are capable of sustained operation with an open laboratory blank which on subsequent analysis has an average of less than 18 structures/mm² in an area of 0.057 mm² (nominally 10 200-mesh grid openings) and a maximum of 53 structures/mm² for any single preparation for that same area.

6. *Cluster* -- A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group. Groupings must have more than two intersections.

7. *ED* -- Electron diffraction.

8. *EDXA* -- Energy dispersive X-ray analysis.

9. *Fiber* -- A structure greater than or equal to 0.5 μm in length with an aspect ratio (length to width) of 5:1 or greater and having substantially parallel sides.

10. *Grid* -- An open structure for mounting on the sample to aid in its examination in the TEM. The term is used here to denote a 200-mesh copper lattice approximately 3 mm in diameter.

11. *Intersection* -- Nonparallel touching or crossing of fibers, with the projection having an aspect ratio of 5:1 or greater.

12. *Laboratory sample coordinator* -- That person responsible for the conduct of sample handling and the certification of the testing procedures.

13. *Filter background level* -- The concentration of structures per square millimeter of filter that is considered indistinguishable from the concentration measured on a blank (filters through which no air has been drawn). For this method the filter background level is defined as 70 structures/mm².

14. *Matrix* -- Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.

15. *NSD* -- No structure detected.

16. *Operator* -- A person responsible for the TEM instrumental analysis of the sample.

17. *PCM* -- Phase contrast microscopy.

18. *SAED* -- Selected area electron diffraction.

19. *SEM* -- Scanning electron microscope.

20. *STEM* -- Scanning transmission electron microscope.

21. *Structure* -- a microscopic bundle, cluster, fiber, or matrix which may contain asbestos.

22. *S/cm³* -- Structures per cubic centimeter.

23. *S/mm²* -- Structures per square millimeter.

24. *TEM* -- Transmission electron microscope. B. Sampling

1. The sampling agency must have written quality control procedures and documents which verify compliance.

2. Sampling operations must be performed by qualified individuals completely independent of the abatement contractor to avoid possible conflict of interest (References 1, 2, 3, and 5 of Unit II.J.).

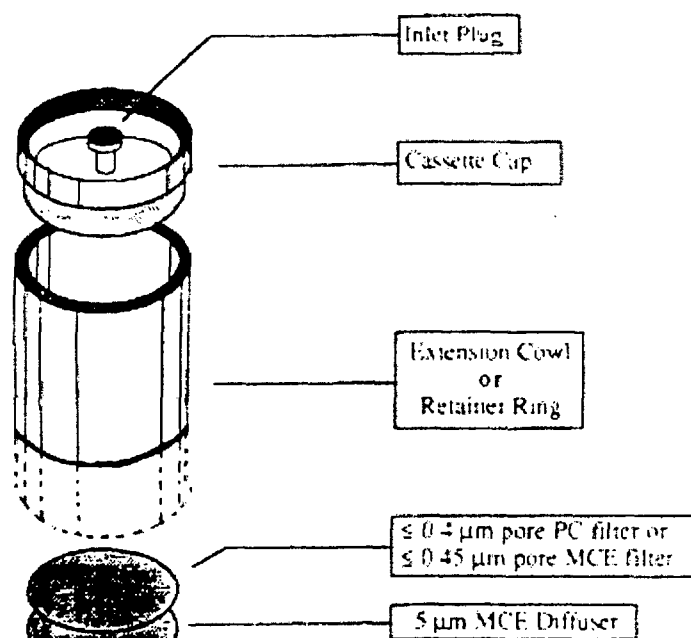
3. Sampling for airborne asbestos following an abatement action must use commercially available cassettes.

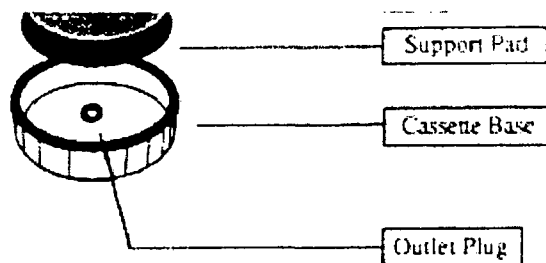
4. Prescreen the loaded cassette collection filters to assure that they do not contain concentrations of asbestos which may interfere with the analysis of the sample. A filter blank average of less than 18 s/mm² in an area of 0.057 mm² (nominally 10 200-mesh grid openings) and a single preparation with a maximum of 53 s/mm² for that same area is acceptable for this method.

5. Use sample collection filters which are either polycarbonate having a pore size less than or equal to 0.4 µm or mixed cellulose ester having a pore size less than or equal to 0.45 µm.

6. Place these filters in series with a 5.0 µm backup filter (to serve as a diffuser) and a support pad. See the following Figure 1:

FIGURE 1--SAMPLING CASSETTE CONFIGURATION





[View or Download PDF](#)

7. Reloading of used cassettes is not permitted.
8. Orient the cassette downward at approximately 45 degrees from the horizontal.
9. Maintain a log of all pertinent sampling information.
10. Calibrate sampling pumps and their flow indicators over the range of their intended use with a recognized standard. Assemble the sampling system with a representative filter (not the filter which will be used in sampling) before and after the sampling operation.
11. Record all calibration information.
12. Ensure that the mechanical vibrations from the pump will be minimized to prevent transferral of vibration to the cassette.
13. Ensure that a continuous smooth flow of negative pressure is delivered by the pump by damping out any pump action fluctuations if necessary.
14. The final plastic barrier around the abatement area remains in place for the sampling period.
15. After the area has passed a thorough visual inspection, use aggressive sampling conditions to dislodge any remaining dust. (See suggested protocol in Unit III.B.7.d.)
16. Select an appropriate flow rate equal to or greater than 1 liter per minute (L/min) or less than 10 L/min for 25 mm cassettes. Larger filters may be operated at proportionally higher flow rates.
17. A minimum of 13 samples are to be collected for each testing site consisting of the following:
 - a. A minimum of five samples per abatement area.
 - b. A minimum of five samples per ambient area positioned at locations representative of the air entering the abatement site.
 - c. Two field blanks are to be taken by removing the cap for not more than 30 seconds and replacing it at the time of sampling before sampling is initiated at the following places:

- i. Near the entrance to each abatement area.
- ii. At one of the ambient sites. (DO NOT leave the field blanks open during the sampling period.)
- d. A sealed blank is to be carried with each sample set. This representative cassette is not to be opened in the field.

18. Perform a leak check of the sampling system at each indoor and outdoor sampling site by activating the pump with the closed sampling cassette in line. Any flow indicates a leak which must be eliminated before initiating the sampling operation.

19. The following Table I specifies volume ranges to be used:

TABLE I--NUMBER OF 100 MESH EM GRID OPENINGS
(0.0057 MM²) THAT NEED TO BE ANALYZED TO
MAINTAIN SENSITIVITY OF 0.005 STRUCTURES/CC
BASED ON VOLUME AND EFFECTIVE FILTER AREA

Effective Filter Area 385 sq mm		Effective Filter Area 855 sq mm	
Volume (liters)	# of grid openings	Volume (liters)	# of grid openings
500	24	1,250	24
600	23	1,300	23
700	19	1,400	21
800	17	1,500	19
900	15	1,600	17
1,000	14	2,000	15
1,100	12	2,250	14
1,200	11	2,400	13
1,300	10	2,600	12
1,400	10	2,800	11
1,500	9	3,000	10
1,600	8	3,200	9
1,700	8	3,400	8
1,800	8	3,600	8
1,900	7	3,800	8
2,000	7	4,000	8
2,100	6	4,200	7
2,200	6	4,400	7
2,300	6	4,600	7
2,400	6	4,800	6
2,500	5	5,000	6
2,600	5	5,200	6
2,700	5	5,400	6
2,800	5	5,600	5
2,900	5	5,800	5
3,000	5	6,000	5
3,100	4	6,200	5
3,200	4	6,400	5
3,300	4	6,600	5
3,400	4	6,800	4
3,500	4	7,000	4
3,600	4	7,200	4
3,700	4	7,400	4
3,800	4	7,600	4

Note minimum volumes required:
25 mm : 580 liters
37 mm : 1250 liters

Filter diameter of 25 mm = effective area of 385 sq mm
Filter diameter of 37 mm = effective area of 855 sq mm

- 20. Ensure that the sampler is turned upright before interrupting the pump flow.
- 21. Check that all samples are clearly labeled and that all pertinent information has been enclosed before transfer of the samples to the laboratory.
- 22. Ensure that the samples are stored in a secure and representative location.
- 23. Do not change containers if portions of these filters are taken for other purposes.
- 24. A summary of Sample Data Quality Objectives is shown in the following Table II:

TABLE 11--SUMMARY OF SAMPLING AGENCY DATA QUALITY OBJECTIVES

This table summarizes the data quality objectives from the performance of this method in terms of precision, accuracy, completeness, representativeness, and comparability. These objectives are assessed by the periodic analytical checks and reference checks listed here and described in the text of the method.

Data Description	QC Check	Frequency	Compliance Expectation
Sampling materials	Sealed blanks	1 per 500 sites	95%
Sample procedures	Field blanks	1 per 500 sites	95%
	Blank calibration	Before and after each field series	95%
Sample custody	Review of chain of custody record	Each sample	95% complete
Sample shipment	Review of shipping report	Each sample	95% complete

C. Sample Shipment

Ship bulk samples to the analytical laboratory in a separate container from air samples. D. Sample Receiving

1. Designate one individual as sample coordinator at the laboratory. While that individual will normally be available to receive samples, the coordinator may train and supervise others in receiving procedures for those times when he/she is not available.

2. Bulk samples and air samples delivered to the analytical laboratory in the same container shall be rejected. E. Sample Preparation

1. All sample preparation and analysis shall be performed by a laboratory independent of the abatement contractor.

2. Wet-wipe the exterior of the cassettes to minimize contamination possibilities before taking them into the clean room facility.

3. Perform sample preparation in a well-equipped clean facility.

>Note: The clean area is required to have the following minimum characteristics. The area or hood must be capable of maintaining a positive pressure with make-up air being HEPA-filtered. The cumulative analytical blank concentration must average less than 18 s/mm² in an area of 0.057 mm² (nominally 10 200-mesh grid openings) and a single preparation with a maximum of 53 s/mm² for that same area.

4. Preparation areas for air samples must not only be separated from preparation areas for bulk samples, but they must be prepared in separate rooms.

5. Direct preparation techniques are required. The object is to produce an intact film containing the particulates of the filter surface which is sufficiently clear for TEM analysis.

a. TEM Grid Opening Area measurement must be done as follows:

i. The filter portion being used for sample preparation must have the surface collapsed using an acetone vapor technique.

ii. Measure 20 grid openings on each of 20 random 200-mesh copper grids by placing a grid on a glass and examining it under the PCM. Use a calibrated graticule to measure the average field

diameters. From the data, calculate the field area for an average grid opening.

iii. Measurements can also be made on the TEM at a properly calibrated low magnification or on an optical microscope at a magnification of approximately 400X by using an eyepiece fitted with a scale that has been calibrated against a stage micrometer. Optical microscopy utilizing manual or automated procedures may be used providing instrument calibration can be verified.

b. TEM specimen preparation from polycarbonate (PC) filters. Procedures as described in Unit III.G. or other equivalent methods may be used.

c. TEM specimen preparation from mixed cellulose ester (MCE) filters.

i. Filter portion being used for sample preparation must have the surface collapsed using an acetone vapor technique or the Burdette procedure (Ref. 7 of Unit II.J.)

ii. Plasma etching of the collapsed filter is required. The microscope slide to which the collapsed filter pieces are attached is placed in a plasma asher. Because plasma ashers vary greatly in their performance, both from unit to unit and between different positions in the asher chamber, it is difficult to specify the conditions that should be used. Insufficient etching will result in a failure to expose embedded filters, and too much etching may result in loss of particulate from the surface. As an interim measure, it is recommended that the time for ashing of a known weight of a collapsed filter be established and that the etching rate be calculated in terms of micrometers per second. The actual etching time used for the particulate asher and operating conditions will then be set such that a 1-2 μm (10 percent) layer of collapsed surface will be removed.

iii. Procedures as described in Unit III. or other equivalent methods may be used to prepare samples.

F. TEM Method

1. An 80-120 kV TEM capable of performing electron diffraction with a fluorescent screen inscribed with calibrated gradations is required. If the TEM is equipped with EDXA it must either have a STEM attachment or be capable of producing a spot less than 250 nm in diameter at crossover. The microscope shall be calibrated routinely for magnification and camera constant.

2. *Determination of Camera Constant and ED Pattern Analysis.* The camera length of the TEM in ED operating mode must be calibrated before ED patterns on unknown samples are observed. This can be achieved by using a carbon-coated grid on which a thin film of gold has been sputtered or evaporated. A thin film of gold is evaporated on the specimen TEM grid to obtain zone-axis ED patterns superimposed with a ring pattern from the polycrystalline gold film. In practice, it is desirable to optimize the thickness of the gold film so that only one or two sharp rings are obtained on the superimposed ED pattern. Thicker gold film would normally give multiple gold rings, but it will tend to mask weaker diffraction spots from the unknown fibrous particulate. Since the unknown d-spacings of most interest in asbestos analysis are those which lie closest to the transmitted beam, multiple gold rings are unnecessary on zone-axis ED patterns. An average camera constant using multiple gold rings can be determined. The camera constant is one-half the diameter of the rings times the interplanar spacing of the ring being measured.

3. *Magnification Calibration.* The magnification calibration must be done at the fluorescent screen. The TEM must be calibrated at the grid opening magnification (if used) and also at the magnification used for fiber counting. This is performed with a cross grating replica (e.g., one containing 2,160

lines/mm). Define a field of view on the fluorescent screen either by markings or physical boundaries. The field of view must be measurable or previously inscribed with a scale or concentric circles (all scales should be metric). A logbook must be maintained, and the dates of calibration and the values obtained must be recorded. The frequency of calibration depends on the past history of the particular microscope. After any maintenance of the microscope that involved adjustment of the power supplied to the lenses or the high-voltage system or the mechanical disassembly of the electron optical column apart from filament exchange, the magnification must be recalibrated. Before the TEM calibration is performed, the analyst must ensure that the cross grating replica is placed at the same distance from the objective lens as the specimens are. For instruments that incorporate a eucentric tilting specimen stage, all specimens and the cross grating replica must be placed at the eucentric position.

4. While not required on every microscope in the laboratory, the laboratory must have either one microscope equipped with energy dispersive X-ray analysis or access to an equivalent system on a TEM in another laboratory.

5. Microscope settings: 80-120 kV, grid assessment 250-1,000X, then 15,000-20,000X screen magnification for analysis.

6. Approximately one-half (0.5) of the predetermined sample area to be analyzed shall be performed on one sample grid preparation and the remaining half on a second sample grid preparation.

7. Individual grid openings with greater than 5 percent openings (holes) or covered with greater than 25 percent particulate matter or obviously having nonuniform loading must not be analyzed.

8. Reject the grid if:

- a. Less than 50 percent of the grid openings covered by the replica are intact.
- b. The replica is doubled or folded.
- c. The replica is too dark because of incomplete dissolution of the filter.

9. *Recording Rules.*

a. Any continuous grouping of particles in which an asbestos fiber with an aspect ratio greater than or equal to 5:1 and a length greater than or equal to 0.5 μm is detected shall be recorded on the count sheet. These will be designated asbestos structures and will be classified as fibers, bundles, clusters, or matrices. Record as individual fibers any contiguous grouping having 0, 1, or 2 definable intersections. Groupings having more than 2 intersections are to be described as cluster or matrix. An intersection is a nonparallel touching or crossing of fibers, with the projection having an aspect ratio of 5:1 or greater. See the following Figure 2:

FIGURE 2--COUNTING GUIDELINES USED IN
DETERMINING ASBESTOS STRUCTURES

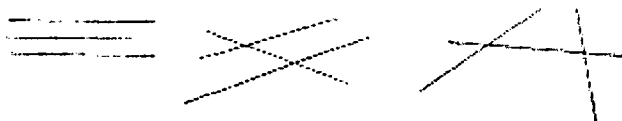
Diagram 1: Fiber 1 structure, no intersections.



Count as 1 fiber if more than one fiber is greater than width of 1 fiber diameter or if the diameter is equal to or less than 1.



Count as 1 structure if space between fibers is greater than width of 1 fiber diameter or if the number of intersections is equal to or less than 2.

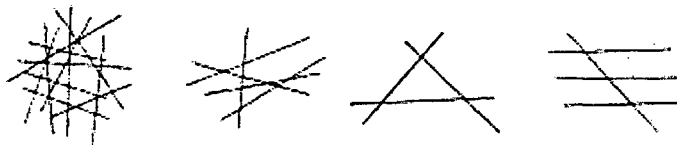


Count bundles as 1 structure; 3 or more parallel fibrils less than 1 fiber diameter separation.

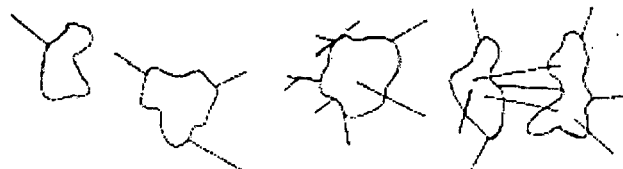


[View or Download PDF](#)

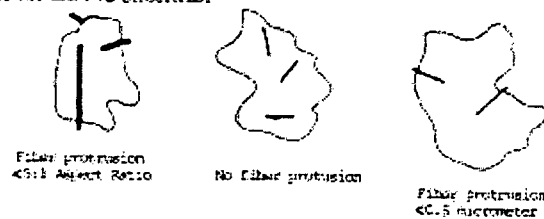
Count clusters as 1 structure; fibers having greater than or equal to 1 intersection.



Count matrix as 1 structure.



DO NOT COUNT AS STRUCTURES.



Fiber protrusion
<9:1 Aspect Ratio

No fiber protrusion

Fiber protrusion
<0.5 micrometer

— <0.5 micrometer in length
— <9:1 Aspect Ratio

[View or Download PDF](#)

- i. *Fiber*. A structure having a minimum length greater than or equal to $0.5\ \mu\text{m}$ and an aspect ratio (length to width) of 5:1 or greater and substantially parallel sides. Note the appearance of the end of the fiber, i.e., whether it is flat, rounded or dovetailed.
- ii. *Bundle*. A structure composed of three or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.
- iii. *Cluster*. A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group. Groupings must have more than two intersections.
- iv. *Matrix*. Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.
- b. Separate categories will be maintained for fibers less than $5\ \mu\text{m}$ and for fibers equal to or greater than $5\ \mu\text{m}$ in length.
- c. Record NSD when no structures are detected in the field.
- d. Visual identification of electron diffraction (ED) patterns is required for each asbestos structure counted which would cause the analysis to exceed the $70\ \text{s/mm}^2$ concentration. (Generally this means the first four fibers identified as asbestos must exhibit an identifiable diffraction pattern for chrysotile or amphibole.)
- e. The micrograph number of the recorded diffraction patterns must be reported to the client and maintained in the laboratory's quality assurance records. In the event that examination of the pattern by a qualified individual indicates that the pattern has been misidentified visually, the client shall be contacted.
- f. Energy Dispersive X-ray Analysis (EDXA) is required of all amphiboles which would cause the analysis results to exceed the $70\ \text{s/mm}^2$ concentration. (Generally speaking, the first 4 amphiboles would require EDXA.)
- g. If the number of fibers in the nonasbestos class would cause the analysis to exceed the $70\ \text{s/mm}^2$ concentration, the fact that they are not asbestos must be confirmed by EDXA or measurement of a zone axis diffraction pattern.
- h. Fibers classified as chrysotile must be identified by diffraction or X-ray analysis and recorded on a count sheet. X-ray analysis alone can be used only after $70\ \text{s/mm}^2$ have been exceeded for a particular sample.
- i. Fibers classified as amphiboles must be identified by X-ray analysis and electron diffraction and recorded on the count sheet. (X-ray analysis alone can be used only after $70\ \text{s/mm}^2$ have been exceeded for a particular sample.)
- j. If a diffraction pattern was recorded on film, record the micrograph number on the count sheet.
- k. If an electron diffraction was attempted but no pattern was observed, record N on the count sheet.

- l. If an EDXA spectrum was attempted but not observed, record N on the count sheet.
- m. If an X-ray analysis spectrum is stored, record the file and disk number on the count sheet.

10. Classification Rules.

- a. *Fiber*. A structure having a minimum length greater than or equal to 0.5 μm and an aspect ratio (length to width) of 5:1 or greater and substantially parallel sides. Note the appearance of the end of the fiber, i.e., whether it is flat, rounded or dovetailed.
- b. *Bundle*. A structure composed of three or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.
- c. *Cluster*. A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group. Groupings must have more than two intersections.
- d. *Matrix*. Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.

11. After finishing with a grid, remove it from the microscope, and replace it in the appropriate grid holder. Sample grids must be stored for a minimum of 1 year from the date of the analysis; the sample cassette must be retained for a minimum of 30 days by the laboratory or returned at the client's request. G. Sample Analytical Sequence

1. Under the present sampling requirements a minimum of 13 samples is to be collected for the clearance testing of an abatement site. These include five abatement area samples, five ambient samples, two field blanks, and one sealed blank.
2. Carry out visual inspection of work site prior to air monitoring.
3. Collect a minimum of 5 air samples inside the work site and 5 samples outside the work site. The indoor and outdoor samples shall be taken during the same time period.
4. Remaining steps in the analytical sequence are contained in Unit IV of this Appendix. H. Reporting

1. The following information must be reported to the client for each sample analyzed:
 - a. Concentration in structures per square millimeter and structures per cubic centimeter.
 - b. Analytical sensitivity used for the analysis.
 - c. Number of asbestos structures.
 - d. Area analyzed.
 - e. Volume of air sampled (which must be initially supplied to lab by client).

- f. Copy of the count sheet must be included with the report.
- g. Signature of laboratory official to indicate that the laboratory met specifications of the method.
- h. Report form must contain official laboratory identification (e.g., letterhead).
- i. Type of asbestos. I. Quality Control/Quality Assurance Procedures (Data Quality Indicators)

Monitoring the environment for airborne asbestos requires the use of sensitive sampling and analysis procedures. Because the test is sensitive, it may be influenced by a variety of factors. These include the supplies used in the sampling operation, the performance of the sampling, the preparation of the grid from the filter and the actual examination of this grid in the microscope. Each of these unit operations must produce a product of defined quality if the analytical result is to be a reliable and meaningful test result. Accordingly, a series of control checks and reference standards are to be performed along with the sample analysis as indicators that the materials used are adequate and the operations are within acceptable limits. In this way, the quality of the data is defined and the results are of known value. These checks and tests also provide timely and specific warning of any problems which might develop within the sampling and analysis operations. A description of these quality control/quality assurance procedures is summarized in the following Table III:

TABLE III--SUMMARY OF LABORATORY DATA QUALITY OBJECTIVES

Unit Operation	QC Check	Frequency	Conformance Expectation
Sample receiving	Review of receiving report	Each sample	95% compliance
Sample storage	Review of chain-of-custody record	Each sample	95% compliance
Sample preparation	Seal integrity and contents	On receipt	Meet specs. or reject
	Grid opening size	20 openings/25 grids/box of 1000 or 5 openings/sample	100%
	Special clean area installation	After cleaning or service	Meet specs. or reject
	Laboratory blank	1 per prep series or 10%	Meet specs. or measure error
	Plasma each blank	1 per 20 samples	75%
	Multiple pieces (2 per sample)	Each sample	One with cover of 15 complete grids sq.
Sample analysis	System check	Each day	Each day
	Alignment check	Each day	Each day
	Magnification calibration with low and high standards	Each month or after service	95%
	EDS calibration by grid standard	Weekly	95%
	EDS calibration by copper line	Daily	95%
Performance checks	Laboratory blank (measure of cleanliness)	Prep 1 per series or 10%; read 1 per 25 samples	Meet specs. or measure error
	Replicate counting (measure of precision)	1 per 100 samples	2.5 x Poisson Std. Dev.
	Duplicate analysis (measure of reproducibility)	1 per 100 samples	2 x Poisson Std. Dev.
	Known samples of typical materials (working standards)	Training and for comparison with unknowns	100%
	Analysis of NBS SRM 1876 under SEM/EDS (measure of accuracy and comparability)	1 per analysis per year	1.5 x Poisson Std. Dev.
	Data entry review (data reduction and measure of completeness)	Each sample	95%
	Record and verify ID to ensure distinction patient or structure	1 per 5 samples	80% accuracy
	Hand calculation of summary data reduction procedure or independent recalculation of hand calculated data	1 per 100 samples	10%
Calibration and data reduction			

1. When the samples arrive at the laboratory, check the samples and documentation for completeness and requirements before initiating the analysis.
2. Check all laboratory reagents and supplies for acceptable asbestos background levels.

3. Conduct all sample preparation in a clean room environment monitored by laboratory blanks. Testing with blanks must also be done after cleaning or servicing the room.
4. Prepare multiple grids of each sample.
5. Provide laboratory blanks with each sample batch. Maintain a cumulative average of these results. If there are more than 53 fibers/mm² per 10 200-mesh grid openings, the system must be checked for possible sources of contamination.
6. Perform a system check on the transmission electron microscope daily.
7. Make periodic performance checks of magnification, electron diffraction and energy dispersive X-ray systems as set forth in Table III under Unit II.I.
8. Ensure qualified operator performance by evaluation of replicate analysis and standard sample comparisons as set forth in Table III under Unit II.I.
9. Validate all data entries.
10. Recalculate a percentage of all computations and automatic data reduction steps as specified in Table III under Unit II.I.
11. Record an electron diffraction pattern of one asbestos structure from every five samples that contain asbestos. Verify the identification of the pattern by measurement or comparison of the pattern with patterns collected from standards under the same conditions. The records must also demonstrate that the identification of the pattern has been verified by a qualified individual and that the operator who made the identification is maintaining at least an 80 percent correct visual identification based on his measured patterns.
12. Appropriate logs or records must be maintained by the analytical laboratory verifying that it is in compliance with the mandatory quality assurance procedures. J. References

For additional background information on this method, the following references should be consulted.

1. "Guidance for Controlling Asbestos-Containing Materials in Buildings," EPA 560/5-85-024, June 1985.
2. "Measuring Airborne Asbestos Following an Abatement Action," USEPA, Office of Pollution Prevention and Toxics, EPA 600/4-85-049, 1985.
3. Small, John and E. Steel. Asbestos Standards: Materials and Analytical Methods. N.B.S. Special Publication 619, 1982.
4. Campbell, W.J., R.L. Blake, L.L. Brown, E.E. Cather, and J.J. Sjoberg. Selected Silicate Minerals and Their Asbestiform Varieties. Information Circular 8751, U.S. Bureau of Mines, 1977.
5. Quality Assurance Handbook for Air Pollution Measurement System. Ambient Air Methods, EPA 600/4-77-027a, USEPA, Office of Research and Development, 1977.

6. Method 2A: Direct Measurement of Gas Volume through Pipes and Small Ducts. 40 CFR Part 60 Appendix A.
7. Burdette, G.J., Health & Safety Exec. Research & Lab. Services Div., London, "Proposed Analytical Method for Determination of Asbestos in Air."
8. Chatfield, E.J., Chatfield Tech. Cons., Ltd., Clark, T., PEI Assoc., "Standard Operating Procedure for Determination of Airborne Asbestos Fibers by Transmission Electron Microscopy Using Polycarbonate Membrane Filters," WERL SOP 87-1, March 5, 1987.
9. NIOSH Method 7402 for Asbestos Fibers, 12-11-86 Draft.
10. Yamate, G., Agarwall, S.C., Gibbons, R.D., IIT Research Institute, "Methodology for the Measurement of Airborne Asbestos by Electron Microscopy," Draft report, USEPA Contract 68-02-3266, July 1984.
11. "Guidance to the Preparation of Quality Assurance Project Plans," USEPA, Office of Pollution Prevention and Toxics, 1984.

III. Nonmandatory Transmission Electron Microscopy Method

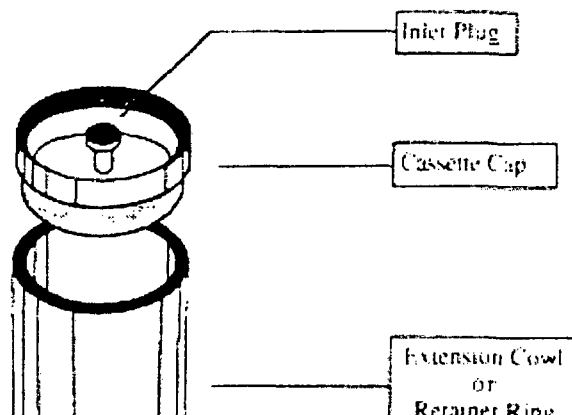
A. Definitions of Terms

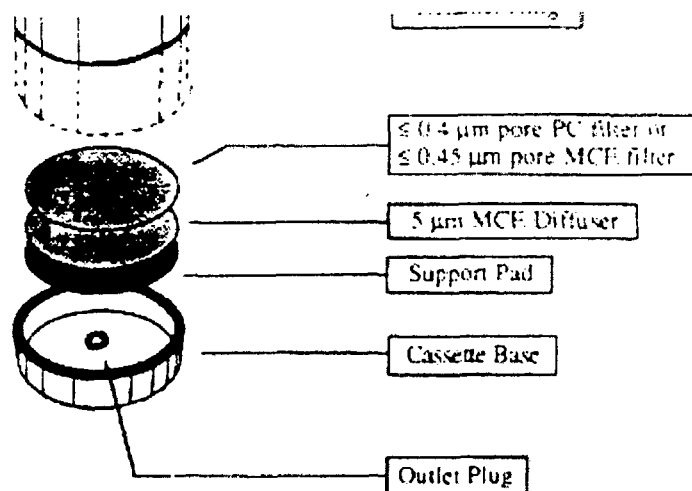
1. *Analytical sensitivity* -- Airborne asbestos concentration represented by each fiber counted under the electron microscope. It is determined by the air volume collected and the proportion of the filter examined. This method requires that the analytical sensitivity be no greater than 0.005 s/cm³.
2. *Asbestiform* -- A specific type of mineral fibrosity in which the fibers and fibrils possess high tensile strength and flexibility.
3. *Aspect ratio* -- A ratio of the length to the width of a particle. Minimum aspect ratio as defined by this method is equal to or greater than 5:1.
4. *Bundle* -- A structure composed of three or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.
5. *Clean area* -- A controlled environment which is maintained and monitored to assure a low probability of asbestos contamination to materials in that space. Clean areas used in this method have HEPA filtered air under positive pressure and are capable of sustained operation with an open laboratory blank which on subsequent analysis has an average of less than 18 structures/mm² in an area of 0.057 mm² (nominally 10 200 mesh grid openings) and a maximum of 53 structures/mm² for no more than one single preparation for that same area.
6. *Cluster* -- A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group. Groupings must have more than two intersections.
7. *ED* -- Electron diffraction.

8. *EDXA* -- Energy dispersive X-ray analysis.
9. *Fiber* -- A structure greater than or equal to 0.5 μm in length with an aspect ratio (length to width) of 5:1 or greater and having substantially parallel sides.
10. *Grid* -- An open structure for mounting on the sample to aid in its examination in the TEM. The term is used here to denote a 200-mesh copper lattice approximately 3 mm in diameter.
11. *Intersection* -- Nonparallel touching or crossing of fibers, with the projection having an aspect ratio of 5:1 or greater.
12. *Laboratory sample coordinator* -- That person responsible for the conduct of sample handling and the certification of the testing procedures.
13. *Filter background level* -- The concentration of structures per square millimeter of filter that is considered indistinguishable from the concentration measured on blanks (filters through which no air has been drawn). For this method the filter background level is defined as 70 structures/mm².
14. *Matrix* -- Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.
15. *NSD* -- No structure detected.
16. *Operator* -- A person responsible for the TEM instrumental analysis of the sample.
17. *PCM* -- Phase contrast microscopy.
18. *SAED* -- Selected area electron diffraction.
19. *SEM* -- Scanning electron microscope.
20. *STEM* -- Scanning transmission electron microscope.
21. *Structure* -- a microscopic bundle, cluster, fiber, or matrix which may contain asbestos.
22. *S/cm³* -- Structures per cubic centimeter.
23. *S/mm²* -- Structures per square millimeter.
24. *TEM* -- Transmission electron microscope. B. Sampling
 1. Sampling operations must be performed by qualified individuals completely independent of the abatement contractor to avoid possible conflict of interest (See References 1, 2, and 5 of Unit III.L.) Special precautions should be taken to avoid contamination of the sample. For example, materials that have not been prescreened for their asbestos background content should not be used; also, sample handling procedures which do not take cross contamination possibilities into account should not be used.

2. Material and supply checks for asbestos contamination should be made on all critical supplies, reagents, and procedures before their use in a monitoring study.
3. Quality control and quality assurance steps are needed to identify problem areas and isolate the cause of the contamination (see Reference 5 of Unit III.L.). Control checks shall be permanently recorded to document the quality of the information produced. The sampling firm must have written quality control procedures and documents which verify compliance. Independent audits by a qualified consultant or firm should be performed once a year. All documentation of compliance should be retained indefinitely to provide a guarantee of quality. A summary of Sample Data Quality Objectives is shown in Table II of Unit II.B.
4. Sampling materials.
 - a. Sample for airborne asbestos following an abatement action using commercially available cassettes.
 - b. Use either a cowl or a filter-retaining middle piece. Conductive material may reduce the potential for particulates to adhere to the walls of the cowl.
 - c. Cassettes must be verified as "clean" prior to use in the field. If packaged filters are used for loading or preloaded cassettes are purchased from the manufacturer or a distributor, the manufacturer's name and lot number should be entered on all field data sheets provided to the laboratory, and are required to be listed on all reports from the laboratory.
 - d. Assemble the cassettes in a clean facility (See definition of clean area under Unit III.A.).
 - e. Reloading of used cassettes is not permitted.
 - f. Use sample collection filters which are either polycarbonate having a pore size of less than or equal to $0.4\ \mu\text{m}$ or mixed cellulose ester having a pore size of less than or equal to $0.45\ \mu\text{m}$.
 - g. Place these filters in series with a backup filter with a pore size of $5.0\ \mu\text{m}$ (to serve as a diffuser) and a support pad. See the following Figure 1:

FIGURE 1--SAMPLING CASSETTE CONFIGURATION





[View or Download PDF](#)

h. When polycarbonate filters are used, position the highly reflective face such that the incoming particulate is received on this surface.

i. Seal the cassettes to prevent leakage around the filter edges or between cassette part joints. A mechanical press may be useful to achieve a reproducible leak-free seal. Shrink fit gel-bands may be used for this purpose and are available from filter manufacturers and their authorized distributors.

j. Use wrinkle-free loaded cassettes in the sampling operation.

5. Pump setup.

a. Calibrate the sampling pump over the range of flow rates and loads anticipated for the monitoring period with this flow measuring device in series. Perform this calibration using guidance from EPA Method 2A each time the unit is sent to the field (See Reference 6 of Unit III.L.).

b. Configure the sampling system to preclude pump vibrations from being transmitted to the cassette by using a sampling stand separate from the pump station and making connections with flexible tubing.

c. Maintain continuous smooth flow conditions by damping out any pump action fluctuations if necessary.

d. Check the sampling system for leaks with the end cap still in place and the pump operating before initiating sample collection. Trace and stop the source of any flow indicated by the flowmeter under these conditions.

e. Select an appropriate flow rate equal to or greater than 1 L/min or less than 10 L/min for 25 mm cassettes. Larger filters may be operated at proportionally higher flow rates.

f. Orient the cassette downward at approximately 45 degrees from the horizontal.

g. Maintain a log of all pertinent sampling information, such as pump identification number, calibration data, sample location, date, sample identification number, flow rates at the beginning, middle, and end, start and stop times, and other useful information or comments. Use of a sampling log form is recommended. See the following Figure 2:

FIGURE 2--SAMPLING LOG FORM

Sample Number	Location of Sample	Pump I.D.	Start Time	Middle Time	End Time	Flow Rate

Inspector: _____ Date: _____

[View or Download PDF](#)

- h. Initiate a chain of custody procedure at the start of each sampling, if this is requested by the client.
- i. Maintain a close check of all aspects of the sampling operation on a regular basis.
- j. Continue sampling until at least the minimum volume is collected, as specified in the following Table I:

TABLE 1--NUMBER OF 200 MESH EM GRID OPENINGS
(0.075 MM) THAT NEED TO BE ANALYZED TO
MAINTAIN SENSITIVITY OF 0.005 STRUCTURES/CC
BASED ON VOLUME AND EFFECTIVE FILTER AREA

Effective Filter Area 385 sq mm		Effective Filter Area 855 sq mm	
Volume (liters)	# of grid openings	Volume (liters)	# of grid openings
560	24	1,250	24
600	23	1,300	23
700	19	1,400	21
800	17	1,600	19
900	15	1,800	17
1,000	14	2,000	15
1,100	12	2,200	14
1,200	11	2,400	13
1,300	10	2,600	12
1,400	10	2,800	11
1,500	9	3,000	10
1,600	8	3,200	9
1,700	8	3,400	8
1,800	8	3,600	8
1,900	7	3,800	8
2,000	7	4,000	8
2,100	6	4,200	7
2,200	6	4,400	7
2,300	6	4,600	7
2,400	6	4,800	6
2,500	5	5,000	6
2,600	5	5,200	6
2,700	5	5,400	6
2,800	5	5,600	5
2,900	5	5,800	5
3,000	5	6,000	5
3,100	4	6,200	5
3,200	4	6,400	5
3,300	4	6,600	5
3,400	4	6,800	4
3,500	4	7,000	4
3,600	4	7,200	4
3,700	4	7,400	4
3,800	4	7,600	4

Note minimum volumes required:
25 mm : 560 liters
37 mm : 1250 liters

Fiber diameter of 25 mm = effective area of 385 sq mm
Fiber diameter of 37 mm = effective area of 855 sq mm

k. At the conclusion of sampling, turn the cassette upward before stopping the flow to minimize possible particle loss. If the sampling is resumed, restart the flow before reorienting the cassette downward. Note the condition of the filter at the conclusion of sampling.

l. Double check to see that all information has been recorded on the data collection forms and that the cassette is securely closed and appropriately identified using a waterproof label. Protect cassettes in individual clean resealed polyethylene bags. Bags are to be used for storing cassette caps when they are removed for sampling purposes. Caps and plugs should only be removed or replaced using clean hands or clean disposable plastic gloves.

m. Do not change containers if portions of these filters are taken for other purposes.

6. Minimum sample number per site. A minimum of 13 samples are to be collected for each testing consisting of the following:

a. A minimum of five samples per abatement area.

b. A minimum of five samples per ambient area positioned at locations representative of the air entering the abatement site.

c. Two field blanks are to be taken by removing the cap for not more than 30 sec and replacing it at the time of sampling before sampling is initiated at the following places:

- i. Near the entrance to each ambient area.
- ii. At one of the ambient sites.

(Note: Do not leave the blank open during the sampling period.)

d. A sealed blank is to be carried with each sample set. This representative cassette is not to be opened in the field.

7. Abatement area sampling.

a. Conduct final clearance sampling only after the primary containment barriers have been removed; the abatement area has been thoroughly dried; and, it has passed visual inspection tests by qualified personnel. (See Reference 1 of Unit III.L.)

b. Containment barriers over windows, doors, and air passageways must remain in place until the TEM clearance sampling and analysis is completed and results meet clearance test criteria. The final plastic barrier remains in place for the sampling period.

c. Select sampling sites in the abatement area on a random basis to provide unbiased and representative samples.

d. After the area has passed a thorough visual inspection, use aggressive sampling conditions to dislodge any remaining dust.

i. Equipment used in aggressive sampling such as a leaf blower and/or fan should be properly cleaned and decontaminated before use.

ii. Air filtration units shall remain on during the air monitoring period.

iii. Prior to air monitoring, floors, ceiling and walls shall be swept with the exhaust of a minimum one (1) horsepower leaf blower.

iv. Stationary fans are placed in locations which will not interfere with air monitoring equipment. Fan air is directed toward the ceiling. One fan shall be used for each 10,000 ft³ of worksite.

v. Monitoring of an abatement work area with high-volume pumps and the use of circulating fans will require electrical power. Electrical outlets in the abatement area may be used if available. If no such outlets are available, the equipment must be supplied with electricity by the use of extension cords and strip plug units. All electrical power supply equipment of this type must be approved Underwriter Laboratory equipment that has not been modified. All wiring must be grounded. Ground fault interrupters should be used. Extreme care must be taken to clean up any residual water and ensure that electrical equipment does not become wet while operational.

vi. Low volume pumps may be carefully wrapped in 6-mil polyethylene to insulate the pump from the air. High volume pumps cannot be sealed in this manner since the heat of the motor may melt the plastic. The pump exhausts should be kept free.

vii. If recleaning is necessary, removal of this equipment from the work area must be handled with care. It is not possible to completely decontaminate the pump motor and parts since these areas cannot be wetted. To minimize any problems in this area, all equipment such as fans and pumps should be carefully wet wiped prior to removal from the abatement area. Wrapping and sealing low volume pumps in 6-mil polyethylene will provide easier decontamination of this equipment. Use of clean water and disposable wipes should be available for this purpose.

e. Pump flow rate equal to or greater than 1 L/min or less than 10 L/min may be used for 25 mm cassettes. The larger cassette diameters may have comparably increased flow.

f. Sample a volume of air sufficient to ensure the minimum quantitation limits. (See Table I of Unit III.B.5.j.)

8. Ambient sampling.

a. Position ambient samplers at locations representative of the air entering the abatement site. If makeup air entering the abatement site is drawn from another area of the building which is outside of the abatement area, place the pumps in the building, pumps should be placed out of doors located near the building and away from any obstructions that may influence wind patterns. If construction is in progress immediately outside the enclosure, it may be necessary to select another ambient site. Samples should be representative of any air entering the work site.

b. Locate the ambient samplers at least 3 ft apart and protect them from adverse weather conditions.

c. Sample same volume of air as samples taken inside the abatement site. C. Sample Shipment

1. Ship bulk samples in a separate container from air samples. Bulk samples and air samples delivered to the analytical laboratory in the same container shall be rejected.

2. Select a rigid shipping container and pack the cassettes upright in a noncontaminating nonfibrous medium such as a bubble pack. The use of resealable polyethylene bags may help to prevent jostling of individual cassettes.

3. Avoid using expanded polystyrene because of its static charge potential. Also avoid using particle-based packaging materials because of possible contamination.

4. Include a shipping bill and a detailed listing of samples shipped, their descriptions and all identifying numbers or marks, sampling data, shipper's name, and contact information. For each sample set, designate which are the ambient samples, which are the abatement area samples, which are the field blanks, and which is the sealed blank if sequential analysis is to be performed.

5. Hand-carry samples to the laboratory in an upright position if possible; otherwise choose that mode of transportation least likely to jar the samples in transit.

6. Address the package to the laboratory sample coordinator by name when known and alert him or her of the package description, shipment mode, and anticipated arrival as part of the chain of custody and sample tracking procedures. This will also help the laboratory schedule timely analysis for the samples when they are received. D. Quality Control/Quality Assurance Procedures (Data Quality

Indicators)

Monitoring the environment for airborne asbestos requires the use of sensitive sampling and analysis procedures. Because the test is sensitive, it may be influenced by a variety of factors. These include the supplies used in the sampling operation, the performance of the sampling, the preparation of the grid from the filter and the actual examination of this grid in the microscope. Each of these unit operations must produce a product of defined quality if the analytical result is to be a reliable and meaningful test result. Accordingly, a series of control checks and reference standards is performed along with the sample analysis as indicators that the materials used are adequate and the operations are within acceptable limits. In this way, the quality of the data is defined, and the results are of known value. These checks and tests also provide timely and specific warning of any problems which might develop within the sampling and analysis operations. A description of these quality control/quality assurance procedures is summarized in the text below.

1. Prescreen the loaded cassette collection filters to assure that they do not contain concentrations of asbestos which may interfere with the analysis of the sample. A filter blank average of less than 18 s/mm² in an area of 0.057 mm² (nominally 10 200-mesh grid openings) and a maximum of 53 s/mm² for that same area for any single preparation is acceptable for this method.
2. Calibrate sampling pumps and their flow indicators over the range of their intended use with a recognized standard. Assemble the sampling system with a representative filter -- not the filter which will be used in sampling -- before and after the sampling operation.
3. Record all calibration information with the data to be used on a standard sampling form.
4. Ensure that the samples are stored in a secure and representative location.
5. Ensure that mechanical calibrations from the pump will be minimized to prevent transferral of vibration to the cassette.
6. Ensure that a continuous smooth flow of negative pressure is delivered by the pump by installing a damping chamber if necessary.
7. Open a loaded cassette momentarily at one of the indoor sampling sites when sampling is initiated. This sample will serve as an indoor field blank.
8. Open a loaded cassette momentarily at one of the outdoor sampling sites when sampling is initiated. This sample will serve as an outdoor field blank.
9. Carry a sealed blank into the field with each sample series. Do not open this cassette in the field.
10. Perform a leak check of the sampling system at each indoor and outdoor sampling site by activating the pump with the closed sampling cassette in line. Any flow indicates a leak which must be eliminated before initiating the sampling operation.
11. Ensure that the sampler is turned upright before interrupting the pump flow.
12. Check that all samples are clearly labeled and that all pertinent information has been enclosed before transfer of the samples to the laboratory. E. Sample Receiving

1. Designate one individual as sample coordinator at the laboratory. While that individual will normally be available to receive samples, the coordinator may train and supervise others in receiving procedures for those times when he/she is not available.
2. Adhere to the following procedures to ensure both the continued chain-of-custody and the accountability of all samples passing through the laboratory:
 - a. Note the condition of the shipping package and data written on it upon receipt.
 - b. Retain all bills of lading or shipping slips to document the shipper and delivery time.
 - c. Examine the chain-of-custody seal, if any, and the package for its integrity.
 - d. If there has been a break in the seal or substantive damage to the package, the sample coordinator shall immediately notify the shipper and a responsible laboratory manager before any action is taken to unpack the shipment.
 - e. Packages with significant damage shall be accepted only by the responsible laboratory manager after discussions with the client.
3. Unwrap the shipment in a clean, uncluttered facility. The sample coordinator or his or her designee will record the contents, including a description of each item and all identifying numbers or marks. A Sample Receiving Form to document this information is attached for use when necessary. (See the following Figure 3.)

FIGURE 3--SAMPLE RECEIVING FORM

Date of package delivery _____	Package shipped from _____
Carrier _____	Shipping bill retained _____
*Condition of package (to receipt) _____	
*Condition of custody seal _____	
Number of samples received _____	Shipping manifest attached _____
Purchase Order No. _____	Project I.D. _____
Comments _____	

No.	Description	Sampling		Sampled Volume	Receiving Date	Assigned to
		PC	MLC			
1	_____	_____	_____	_____	_____	_____
2	_____	_____	_____	_____	_____	_____
3	_____	_____	_____	_____	_____	_____
4	_____	_____	_____	_____	_____	_____
5	_____	_____	_____	_____	_____	_____
6	_____	_____	_____	_____	_____	_____
7	_____	_____	_____	_____	_____	_____
8	_____	_____	_____	_____	_____	_____
9	_____	_____	_____	_____	_____	_____
10	_____	_____	_____	_____	_____	_____
11	_____	_____	_____	_____	_____	_____
12	_____	_____	_____	_____	_____	_____
13	(Use as many additional sheets as needed.)					

Comments _____

Date of acceptance into sample bank _____

Signature of chain-of-custody recipient _____

DISPOSAL OF SAMPLES
*Note: If the package has remained unopened, the custody seal is broken, ruptured, or damaged, the project manager and the shipper

[View or Download PDF](#)

Note: The person breaking the chain-of-custody seal and itemizing the contents assumes responsibility for the shipment and signs documents accordingly.

4. Assign a laboratory number and schedule an analysis sequence.

5. Manage all chain-of-custody samples within the laboratory such that their integrity can be ensured and documented. F. Sample Preparation

1. Personnel not affiliated with the Abatement Contractor shall be used to prepare samples and conduct TEM analysis. Wet-wipe the exterior of the cassettes to minimize contamination possibilities before taking them to the clean sample preparation facility.

2. Perform sample preparation in a well-equipped clean facility.

Note: The clean area is required to have the following minimum characteristics. The area or hood must be capable of maintaining a positive pressure with make-up air being HEPA filtered. The cumulative analytical blank concentration must average less than 18 s/mm² in an area of 0.057 s/mm² (nominally 10 200-mesh grid openings) with no more than one single preparation to exceed 53 s/mm² for that same area.

3. Preparation areas for air samples must be separated from preparation areas for bulk samples. Personnel must not prepare air samples if they have previously been preparing bulk samples without performing appropriate personal hygiene procedures, i.e., clothing change, showering, etc.

4. *Preparation.* Direct preparation techniques are required. The objective is to produce an intact carbon film containing the particulates from the filter surface which is sufficiently clear for TEM analysis. Currently recommended direct preparation procedures for polycarbonate (PC) and mixed cellulose ester (MCE) filters are described in Unit III.F.7. and 8. Sample preparation is a subject requiring additional research. Variation on those steps which do not substantively change the procedure, which improve filter clearing or which reduce contamination problems in a laboratory are permitted.

a. Use only TEM grids that have had grid opening areas measured according to directions in Unit III.J.

b. Remove the inlet and outlet plugs prior to opening the cassette to minimize any pressure differential that may be present.

c. Examples of techniques used to prepare polycarbonate filters are described in Unit III.F.7.

d. Examples of techniques used to prepare mixed cellulose ester filters are described in Unit III.F.8.

e. Prepare multiple grids for each sample.

f. Store the three grids to be measured in appropriately labeled grid holders or polyethylene capsules.

5. Equipment.

a. Clean area.

b. Tweezers. Fine-point tweezers for handling of filters and TEM grids.

c. Scalpel Holder and Curved No. 10 Surgical Blades.

d. Microscope slides.

e. Double-coated adhesive tape.

f. Gummed page reinforcements.

g. Micro-pipet with disposal tips 10 to 100 μ L variable volume.

h. Vacuum coating unit with facilities for evaporation of carbon. Use of a liquid nitrogen cold trap above the diffusion pump will minimize the possibility of contamination of the filter surface by oil from the pumping system. The vacuum-coating unit can also be used for deposition of a thin film of gold.

i. *Carbon rod electrodes*. Spectrochemically pure carbon rods are required for use in the vacuum evaporator for carbon coating of filters.

j. *Carbon rod sharpener*. This is used to sharpen carbon rods to a neck. The use of necked carbon rods (or equivalent) allows the carbon to be applied to the filters with a minimum of heating.

k. *Low-temperature plasma asher*. This is used to etch the surface of collapsed mixed cellulose ester (MCE) filters. The asher should be supplied with oxygen, and should be modified as necessary to provide a throttle or bleed valve to control the speed of the vacuum to minimize disturbance of the filter. Some early models of ashers admit air too rapidly, which may disturb particulates on the surface of the filter during the etching step.

l. *Glass petri dishes, 10 cm in diameter, 1 cm high*. For prevention of excessive evaporation of solvent when these are in use, a good seal must be provided between the base and the lid. The seal can be improved by grinding the base and lid together with an abrasive grinding material.

m. Stainless steel mesh.

n. Lens tissue.

o. Copper 200-mesh TEM grids, 3 mm in diameter, or equivalent.

p. Gold 200-mesh TEM grids, 3 mm in diameter, or equivalent.

- q. Condensation washer.
- r. Carbon-coated, 200-mesh TEM grids, or equivalent.
- s. Analytical balance, 0.1 mg sensitivity.
- t. Filter paper, 9 cm in diameter.
- u. Oven or slide warmer. Must be capable of maintaining a temperature of 65-70 °C.
- v. Polyurethane foam, 6 mm thickness.
- w. Gold wire for evaporation.

6. Reagents.

a. *General.* A supply of ultra-clean, fiber-free water must be available for washing of all components used in the analysis. Water that has been distilled in glass or filtered or deionized water is satisfactory for this purpose. Reagents must be fiber-free.

b. Polycarbonate preparation method -- chloroform.

c. Mixed Cellulose Ester (MCE) preparation method -- acetone or the Burdette procedure (Ref. 7 of Unit III.L.).

7. TEM specimen preparation from polycarbonate filters.

a. *Specimen preparation laboratory.* It is most important to ensure that contamination of TEM specimens by extraneous asbestos fibers is minimized during preparation.

b. Cleaning of sample cassettes. Upon receipt at the analytical laboratory and before they are taken into the clean facility or laminar flow hood, the sample cassettes must be cleaned of any contamination adhering to the outside surfaces.

c. Preparation of the carbon evaporator. If the polycarbonate filter has already been carbon-coated prior to receipt, the carbon coating step will be omitted, unless the analyst believes the carbon film is too thin. If there is a need to apply more carbon, the filter will be treated in the same way as an uncoated filter. Carbon coating must be performed with a high-vacuum coating unit. Units that are based on evaporation of carbon filaments in a vacuum generated only by an oil rotary pump have not been evaluated for this application, and must not be used. The carbon rods should be sharpened by a carbon rod sharpener to necks of about 4 mm long and 1 mm in diameter. The rods are installed in the evaporator in such a manner that the points are approximately 10 to 12 cm from the surface of a microscope slide held in the rotating and tilting device.

d. Selection of filter area for carbon coating. Before preparation of the filters, a 75 mm×50 mm microscope slide is washed and dried. This slide is used to support strips of filter during the carbon evaporation. Two parallel strips of double-sided adhesive tape are applied along the length of the slide. Polycarbonate filters are easily stretched during handling, and cutting of areas for further

preparation must be performed with great care. The filter and the MCE backing filter are removed together from the cassette and placed on a cleaned glass microscope slide. The filter can be cut with a curved scalpel blade by rocking the blade from the point placed in contact with the filter. The process can be repeated to cut a strip approximately 3 mm wide across the diameter of the filter. The strip of polycarbonate filter is separated from the corresponding strip of backing filter and carefully placed so that it bridges the gap between the adhesive tape strips on the microscope slide. The filter strip can be held with fine-point tweezers and supported underneath by the scalpel blade during placement on the microscope slide. The analyst can place several such strips on the same microscope slide, taking care to rinse and wet-wipe the scalpel blade and tweezers before handling a new sample. The filter strips should be identified by etching the glass slide or marking the slide using a marker insoluble in water and solvents. After the filter strip has been cut from each filter, the residual parts of the filter must be returned to the cassette and held in position by reassembly of the cassette. The cassette will then be archived for a period of 30 days or returned to the client upon request.

e. Carbon coating of filter strips. The glass slide holding the filter strips is placed on the rotation-tilting device, and the evaporator chamber is evacuated. The evaporation must be performed in very short bursts, separated by some seconds to allow the electrodes to cool. If evaporation is too rapid, the strips of polycarbonate filter will begin to curl, which will lead to cross-linking of the surface material and make it relatively insoluble in chloroform. An experienced analyst can judge the thickness of carbon film to be applied, and some test should be made first on unused filters. If the film is too thin, large particles will be lost from the TEM specimen, and there will be few complete and undamaged grid openings on the specimen. If the coating is too thick, the filter will tend to curl when exposed to chloroform vapor and the carbon film may not adhere to the support mesh. Too thick a carbon film will also lead to a TEM image that is lacking in contrast, and the ability to obtain ED patterns will be compromised. The carbon film should be as thin as possible and remain intact on most of the grid openings of the TEM specimen intact.

f. Preparation of the Jaffe washer. The precise design of the Jaffe washer is not considered important, so any one of the published designs may be used. A washer consisting of a simple stainless steel bridge is recommended. Several pieces of lens tissue approximately 1.0 cm×0.5 cm are placed on the stainless steel bridge, and the washer is filled with chloroform to a level where the meniscus contacts the underside of the mesh, which results in saturation of the lens tissue. See References 8 and 10 of Unit III.L.

g. Placing of specimens into the Jaffe washer. The TEM grids are first placed on a piece of lens tissue so that individual grids can be picked up with tweezers. Using a curved scalpel blade, the analyst excises three 3 mm square pieces of the carbon-coated polycarbonate filter from the filter strip. The three squares are selected from the center of the strip and from two points between the outer periphery of the active surface and the center. The piece of filter is placed on a TEM specimen grid with the shiny side of the TEM grid facing upwards, and the whole assembly is placed boldly onto the saturated lens tissue in the Jaffe washer. If carbon-coated grids are used, the filter should be placed carbon-coated side down. The three excised squares of filters are placed on the same piece of lens tissue. Any number of separate pieces of lens tissue may be placed in the same Jaffe washer. The lid is then placed on the Jaffe washer, and the system is allowed to stand for several hours, preferably overnight.

h. *Condensation washing.* It has been found that many polycarbonate filters will not dissolve completely in the Jaffe washer, even after being exposed to chloroform for as long as 3 days. This problem becomes more serious if the surface of the filter was overheated during the carbon

evaporation. The presence of undissolved filter medium on the TEM preparation leads to partial or complete obscuration of areas of the sample, and fibers that may be present in these areas of the specimen will be overlooked; this will lead to a low result. Undissolved filter medium also compromises the ability to obtain ED patterns. Before they are counted, TEM grids must be examined critically to determine whether they are adequately cleared of residual filter medium. It has been found that condensation washing of the grids after the initial Jaffe washer treatment, with chloroform as the solvent, clears all residual filter medium in a period of approximately 1 hour. In practice, the piece of lens tissue supporting the specimen grids is transferred to the cold finger of the condensation washer, and the washer is operated for about 1 hour. If the specimens are cleared satisfactorily by the Jaffe washer alone, the condensation washer step may be unnecessary.

8. TEM specimen preparation from MCE filters.

a. This method of preparing TEM specimens from MCE filters is similar to that specified in NIOSH Method 7402. See References 7, 8, and 9 of Unit III.L.

b. Upon receipt at the analytical laboratory, the sample cassettes must be cleaned of any contamination adhering to the outside surfaces before entering the clean sample preparation area.

c. Remove a section from any quadrant of the sample and blank filters.

d. Place the section on a clean microscope slide. Affix the filter section to the slide with a gummed paged reinforcement or other suitable means. Label the slide with a water and solvent-proof marking pen.

e. Place the slide in a petri dish which contains several paper filters soaked with 2 to 3 mL acetone. Cover the dish. Wait 2 to 4 minutes for the sample filter to fuse and clear.

f. Plasma etching of the collapsed filter is required.

i. The microscope slide to which the collapsed filter pieces are attached is placed in a plasma asher. Because plasma ashers vary greatly in their performance, both from unit to unit and between different positions in the asher chamber, it is difficult to specify the conditions that should be used. This is one area of the method that requires further evaluation. Insufficient etching will result in a failure to expose embedded filters, and too much etching may result in loss of particulate from the surface. As an interim measure, it is recommended that the time for ashing of a known weight of a collapsed filter be established and that the etching rate be calculated in terms of micrometers per second. The actual etching time used for a particular asher and operating conditions will then be set such that a 1-2 μm (10 percent) layer of collapsed surface will be removed.

ii. Place the slide containing the collapsed filters into a low-temperature plasma asher, and etch the filter.

g. Transfer the slide to a rotating stage inside the bell jar of a vacuum evaporator. Evaporate a 1 mm \times 5 mm section of graphite rod onto the cleared filter. Remove the slide to a clean, dry, covered petri dish.

h. Prepare a second petri dish as a Jaffe washer with the wicking substrate prepared from filter or lens paper placed on top of a 6 mm thick disk of clean spongy polyurethane foam. Cut a V-notch on the

edge of the foam and filter paper. Use the V-notch as a reservoir for adding solvent. The wicking substrate should be thin enough to fit into the petri dish without touching the lid.

i. Place carbon-coated TEM grids face up on the filter or lens paper. Label the grids by marking with a pencil on the filter paper or by putting registration marks on the petri dish lid and marking with a waterproof marker on the dish lid. In a fume hood, fill the dish with acetone until the wicking substrate is saturated. The level of acetone should be just high enough to saturate the filter paper without creating puddles.

j. Remove about a quarter section of the carbon-coated filter samples from the glass slides using a surgical knife and tweezers. Carefully place the section of the filter, carbon side down, on the appropriately labeled grid in the acetone-saturated petri dish. When all filter sections have been transferred, slowly add more solvent to the wedge-shaped trough to bring the acetone level up to the highest possible level without disturbing the sample preparations. Cover the petri dish. Elevate one side of the petri dish by placing a slide under it. This allows drops of condensed solvent vapors to form near the edge rather than in the center where they would drip onto the grid preparation. G. TEM Method

1. *Instrumentation.*

a. Use an 80-120 kV TEM capable of performing electron diffraction with a fluorescent screen inscribed with calibrated gradations. If the TEM is equipped with EDXA it must either have a STEM attachment or be capable of producing a spot less than 250 nm in diameter at crossover. The microscope shall be calibrated routinely (see Unit III.J.) for magnification and camera constant.

b. While not required on every microscope in the laboratory, the laboratory must have either one microscope equipped with energy dispersive X-ray analysis or access to an equivalent system on a TEM in another laboratory. This must be an Energy Dispersive X-ray Detector mounted on TEM column and associated hardware/software to collect, save, and read out spectral information. Calibration of Multi-Channel Analyzer shall be checked regularly for Al at 1.48 KeV and Cu at 8.04 KeV, as well as the manufacturer's procedures.

i. Standard replica grating may be used to determine magnification (e.g., 2160 lines/mm).

ii. Gold standard may be used to determine camera constant.

c. Use a specimen holder with single tilt and/or double tilt capabilities.

2. *Procedure.*

a. Start a new Count Sheet for each sample to be analyzed. Record on count sheet: analyst's initials and date; lab sample number; client sample number microscope identification; magnification for analysis; number of predetermined grid openings to be analyzed; and grid identification. See the following Figure 4:

Line Sample No. _____	Filter Type _____	Operator _____
Control Sample No. _____	Filter Area _____	Units _____
Sampled At _____	Control _____	Comments _____
Machine _____	Start/Stop Date/Time _____	
Line Voltage _____	No. Gallons Sampled _____	

[illegible][illegible]

*B = Brazil
C = Canada
F = France
M = Mexico

NFD = No factors derived
N = No difference observed

[View or Download PDF](#)

- b. Check that the microscope is properly aligned and calibrated according to the manufacturer's specifications and instructions.
- c. Microscope settings: 80-120 kV, grid assessment 250-1000X, then 15,000-20,000X screen magnification for analysis.
- d. Approximately one-half (0.5) of the predetermined sample area to be analyzed shall be performed on one sample grid preparation and the remaining half on a second sample grid preparation.
- e. Determine the suitability of the grid.
 - i. Individual grid openings with greater than 5 percent openings (holes) or covered with greater than 25 percent particulate matter or obviously having nonuniform loading shall not be analyzed.
 - ii. Examine the grid at low magnification (<1000X) to determine its suitability for detailed study at higher magnifications.
 - iii. Reject the grid if:

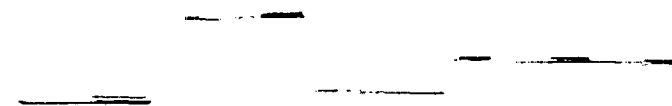
- (1) Less than 50 percent of the grid openings covered by the replica are intact.
 - (2) It is doubled or folded.
 - (3) It is too dark because of incomplete dissolution of the filter.
- iv. If the grid is rejected, load the next sample grid.
 - v. If the grid is acceptable, continue on to Step 6 if mapping is to be used; otherwise proceed to Step 7.
- f. Grid Map (Optional).
 - i. Set the TEM to the low magnification mode.
 - ii. Use flat edge or finder grids for mapping.
 - iii. Index the grid openings (fields) to be counted by marking the acceptable fields for one-half (0.5) of the area needed for analysis on each of the two grids to be analyzed. These may be marked just before examining each grid opening (field), if desired.
 - iv. Draw in any details which will allow the grid to be properly oriented if it is reloaded into the microscope and a particular field is to be reliably identified.
 - g. Scan the grid.
 - i. Select a field to start the examination.
 - ii. Choose the appropriate magnification (15,000 to 20,000X screen magnification).
 - iii. Scan the grid as follows.
 - (1) At the selected magnification, make a series of parallel traverses across the field. On reaching the end of one traverse, move the image one window and reverse the traverse.

Note: A slight overlap should be used so as not to miss any part of the grid opening (field).

 - (2) Make parallel traverses until the entire grid opening (field) has been scanned.
 - h. Identify each structure for appearance and size.
 - i. Appearance and size: Any continuous grouping of particles in which an asbestos fiber within aspect ratio greater than or equal to 5:1 and a length greater than or equal to 0.5 μm is detected shall be recorded on the count sheet. These will be designated asbestos structures and will be classified as fibers, bundles, clusters, or matrices. Record as individual fibers any contiguous grouping having 0, 1, or 2 definable intersections. Groupings having more than 2 intersections are to be described as cluster or matrix. See the following Figure 5:

FIGURE 1. FIBER STRUCTURE IDENTIFICATION

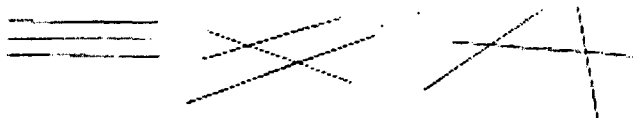
Count as 1 fiber, 1 structure or intersection.



Count as 1 fiber if space between fibers is greater than width of 1 fiber; diameter or width of intersection is equal to or less than 1.



Count as 1 structure if space between fibers is greater than width of 1 fiber; diameter or if the number of intersections is equal to or less than 2.

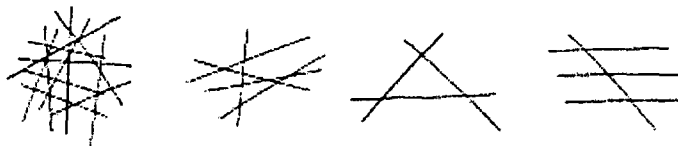


Count bundle as 1 structure: 5 or more parallel fibrils less than 1 fiber diameter separation.

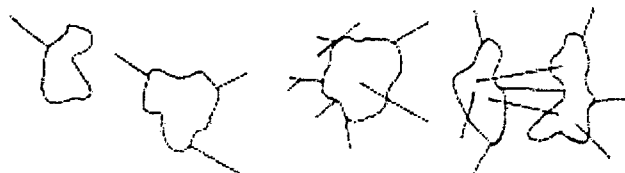


[View or Download PDF](#)

Count clusters as 1 structure: fibers having greater than or equal to 3 intersections.



Count matrix as 1 structure.



DO NOT COUNT AS STRUCTURES:



Fiber protrusion
45:1 Aspect Ratio

No fiber protrusion

Fiber projection
<0.5 micrometer— <0.5 micrometer in length
— <5:1 Aspect Ratio[View or Download PDF](#)

An intersection is a non-parallel touching or crossing of fibers, with the projection having an aspect ratio of 5:1 or greater. Combinations such as a matrix and cluster, matrix and bundle, or bundle and cluster are categorized by the dominant fiber quality -- cluster, bundle, and matrix, respectively. Separate categories will be maintained for fibers less than 5 μm and for fibers greater than or equal to 5 μm in length. Not required, but useful, may be to record the fiber length in 1 μm intervals. (Identify each structure morphologically and analyze it as it enters the "window".)

- (1) *Fiber*. A structure having a minimum length greater than 0.5 μm and an aspect ratio (length to width) of 5:1 or greater and substantially parallel sides. Note the appearance of the end of the fiber, i.e., whether it is flat, rounded or dovetailed, no intersections.
- (2) *Bundle*. A structure composed of 3 or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.
- (3) *Cluster*. A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group; groupings must have more than 2 intersections.
- (4) *Matrix*. Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.
- (5) *NSD*. Record NSD when no structures are detected in the field.
- (6) *Intersection*. Non-parallel touching or crossing of fibers, with the projection having an aspect ratio 5:1 or greater.

ii. Structure Measurement.

- (1) Recognize the structure that is to be sized.
- (2) Memorize its location in the "window" relative to the sides, inscribed square and to other particulates in the field so this exact location can be found again when scanning is resumed.
- (3) Measure the structure using the scale on the screen.
- (4) Record the length category and structure type classification on the count sheet after the field number and fiber number.
- (5) Return the fiber to its original location in the window and scan the rest of the field for other fibers; if the direction of travel is not remembered, return to the right side of the field and begin the traverse again.

i. Visual identification of Electron Diffraction (ED) patterns is required for each asbestos structure counted which would cause the analysis to exceed the 70 s/mm² concentration. (Generally this means the first four fibers identified as asbestos must exhibit an identifiable diffraction pattern for chrysotile or amphibole.)

i. Center the structure, focus, and obtain an ED pattern. (See Microscope Instruction Manual for more detailed instructions.)

ii. From a visual examination of the ED pattern, obtained with a short camera length, classify the observed structure as belonging to one of the following classifications: chrysotile, amphibole, or nonasbestos.

(1) Chrysotile: The chrysotile asbestos pattern has characteristic streaks on the layer lines other than the central line and some streaking also on the central line. There will be spots of normal sharpness on the central layer line and on alternate lines (2nd, 4th, etc.). The repeat distance between layer lines is 0.53 nm and the center doublet is at 0.73 nm. The pattern should display (002), (110), (130) diffraction maxima; distances and geometry should match a chrysotile pattern and be measured semiquantitatively.

(2) Amphibole Group [includes grunerite (amosite), crocidolite, anthophyllite, tremolite, and actinolite]: Amphibole asbestos fiber patterns show layer lines formed by very closely spaced dots, and the repeat distance between layer lines is also about 0.53 nm. Streaking in layer lines is occasionally present due to crystal structure defects.

(3) Nonasbestos: Incomplete or unobtainable ED patterns, a nonasbestos EDXA, or a nonasbestos morphology.

iii. The micrograph number of the recorded diffraction patterns must be reported to the client and maintained in the laboratory's quality assurance records. The records must also demonstrate that the identification of the pattern has been verified by a qualified individual and that the operator who made the identification is maintaining at least an 80 percent correct visual identification based on his measured patterns. In the event that examination of the pattern by the qualified individual indicates that the pattern had been misidentified visually, the client shall be contacted. If the pattern is a suspected chrysotile, take a photograph of the diffraction pattern at 0 degrees tilt. If the structure is suspected to be amphibole, the sample may have to be tilted to obtain a simple geometric array of spots.

j. Energy Dispersive X-Ray Analysis (EDXA).

i. Required of all amphiboles which would cause the analysis results to exceed the 70 s/mm² concentration. (Generally speaking, the first 4 amphiboles would require EDXA.)

ii. Can be used alone to confirm chrysotile after the 70 s/mm² concentration has been exceeded.

iii. Can be used alone to confirm all nonasbestos.

iv. Compare spectrum profiles with profiles obtained from asbestos standards. The closest match identifies and categorizes the structure.

v. If the EDXA is used for confirmation, record the properly labeled spectrum on a computer disk, or if a hard copy, file with analysis data.

vi. If the number of fibers in the nonasbestos class would cause the analysis to exceed the 70 s/mm² concentration, their identities must be confirmed by EDXA or measurement of a zone axis diffraction pattern to establish that the particles are nonasbestos.

k. Stopping Rules.

i. If more than 50 asbestiform structures are counted in a particular grid opening, the analysis may be terminated.

ii. After having counted 50 asbestiform structures in a minimum of 4 grid openings, the analysis may be terminated. The grid opening in which the 50th fiber was counted must be completed.

iii. For blank samples, the analysis is always continued until 10 grid openings have been analyzed.

iv. In all other samples the analysis shall be continued until an analytical sensitivity of 0.005 s/cm³ is reached.

l. Recording Rules. The count sheet should contain the following information:

i. Field (grid opening): List field number.

ii. Record "NSD" if no structures are detected.

iii. Structure information.

(1) If fibers, bundles, clusters, and/or matrices are found, list them in consecutive numerical order, starting over with each field.

(2) Length. Record length category of asbestos fibers examined. Indicate if less than 5 μ m or greater than or equal to 5 μ m.

(3) Structure Type. Positive identification of asbestos fibers is required by the method. At least one diffraction pattern of each fiber type from every five samples must be recorded and compared with a standard diffraction pattern. For each asbestos fiber reported, both a morphological descriptor and an identification descriptor shall be specified on the count sheet.

(4) Fibers classified as chrysotile must be identified by diffraction and/or X-ray analysis and recorded on the count sheet. X-ray analysis alone can be used as sole identification only after 70s/mm² have been exceeded for a particular sample.

(5) Fibers classified as amphiboles must be identified by X-ray analysis and electron diffraction and recorded on the count sheet. (X-ray analysis alone can be used as sole identification only after 70s/mm² have been exceeded for a particular sample.)

(6) If a diffraction pattern was recorded on film, the micrograph number must be indicated on the

count sheet.

(7) If an electron diffraction was attempted and an appropriate spectra is not observed, N should be recorded on the count sheet.

(8) If an X-ray analysis is attempted but not observed, N should be recorded on the count sheet.

(9) If an X-ray analysis spectrum is stored, the file and disk number must be recorded on the count sheet.

m. Classification Rules.

i. *Fiber*. A structure having a minimum length greater than or equal to 0.5 μm and an aspect ratio (length to width) of 5:1 or greater and substantially parallel sides. Note the appearance of the end of the fiber, i.e., whether it is flat, rounded or dovetailed.

ii. *Bundle*. A structure composed of three or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.

iii. *Cluster*. A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group. Groupings must have more than two intersections.

iv. *Matrix*. Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.

v. *NSD*. Record NSD when no structures are detected in the field.

n. After all necessary analyses of a particle structure have been completed, return the goniometer stage to 0 degrees, and return the structure to its original location by recall of the original location.

o. Continue scanning until all the structures are identified, classified and sized in the field.

p. Select additional fields (grid openings) at low magnification; scan at a chosen magnification (15,000 to 20,000X screen magnification); and analyze until the stopping rule becomes applicable.

q. Carefully record all data as they are being collected, and check for accuracy.

r. After finishing with a grid, remove it from the microscope, and replace it in the appropriate grid hold. Sample grids must be stored for a minimum of 1 year from the date of the analysis; the sample cassette must be retained for a minimum of 30 days by the laboratory or returned at the client's request. H. Sample Analytical Sequence

1. Carry out visual inspection of work site prior to air monitoring.

2. Collect a minimum of five air samples inside the work site and five samples outside the work site. The indoor and outdoor samples shall be taken during the same time period.

3. Analyze the abatement area samples according to this protocol. The analysis must meet the 0.005 s/cm³ analytical sensitivity.

The following information must be reported to the client. See the following Table II:

TABLE II--SAMPLE LIBRARY LETTERHEAD

[illegible]

INDIVIDUAL ANALYTICAL RESULTS

[illegible]

The analysis was carried out in the approved TEM method. This laboratory is in compliance with the quality specified by the method.

Aufgabenstellung

[View or Download PDF](#)

1. Concentration in structures per square millimeter and structures per cubic centimeter.
2. Analytical sensitivity used for the analysis.
3. Number of asbestos structures.
4. Area analyzed.
5. Volume of air samples (which was initially provided by client).
6. Average grid size opening.
7. Number of grids analyzed.
8. Copy of the count sheet must be included with the report.

9. Signature of laboratory official to indicate that the laboratory met specifications of the AHERA method.

10. Report form must contain official laboratory identification (e.g., letterhead).

11. Type of asbestos. J. Calibration Methodology

Note: Appropriate implementation of the method requires a person knowledgeable in electron diffraction and mineral identification by ED and EDXA. Those inexperienced laboratories wishing to develop capabilities may acquire necessary knowledge through analysis of appropriate standards and by following detailed methods as described in References 8 and 10 of Unit III.L.

1. *Equipment Calibration.* In this method, calibration is required for the air-sampling equipment and the transmission electron microscope (TEM).

a. *TEM Magnification.* The magnification at the fluorescent screen of the TEM must be calibrated at the grid opening magnification (if used) and also at the magnification used for fiber counting. This is performed with a cross grating replica. A logbook must be maintained, and the dates of calibration depend on the past history of the particular microscope; no frequency is specified. After any maintenance of the microscope that involved adjustment of the power supplied to the lenses or the high-voltage system or the mechanical disassembly of the electron optical column apart from filament exchange, the magnification must be recalibrated. Before the TEM calibration is performed, the analyst must ensure that the cross grating replica is placed at the same distance from the objective lens as the specimens are. For instruments that incorporate an eucentric tilting specimen stage, all specimens and the cross grating replica must be placed at the eucentric position.

b. Determination of the TEM magnification on the fluorescent screen.

i. Define a field of view on the fluorescent screen either by markings or physical boundaries. The field of view must be measurable or previously inscribed with a scale or concentric circles (all scales should be metric).

ii. Insert a diffraction grating replica (for example a grating containing 2,160 lines/mm) into the specimen holder and place into the microscope. Orient the replica so that the grating lines fall perpendicular to the scale on the TEM fluorescent screen. Ensure that the goniometer stage tilt is 0 degrees.

iii. Adjust microscope magnification to 10,000X or 20,000X. Measure the distance (mm) between two widely separated lines on the grating replica. Note the number of spaces between the lines. Take care to measure between the same relative positions on the lines (e.g., between left edges of lines).

Note: The more spaces included in the measurement, the more accurate the final calculation. On most microscopes, however, the magnification is substantially constant only within the central 8-10 cm diameter region of the fluorescent screen.

iv. Calculate the true magnification (M) on the fluorescent screen:

M = XG/S

M-AG/1

where:

X=total distance (mm) between the designated grating lines;

G=calibration constant of the grating replica (lines/mm):

Y=number of grating replica spaces counted along X.

c. Calibration of the EDXA System. Initially, the EDXA system must be calibrated by using two reference elements to calibrate the energy scale of the instrument. When this has been completed in accordance with the manufacturer's instructions, calibration in terms of the different types of asbestos can proceed. The EDXA detectors vary in both solid angle of detection and in window thickness. Therefore, at a particular accelerating voltage in use on the TEM, the count rate obtained from specific dimensions of fiber will vary both in absolute X-ray count rate and in the relative X-ray peak heights for different elements. Only a few minerals are relevant for asbestos abatement work, and in this procedure the calibration is specified in terms of a "fingerprint" technique. The EDXA spectra must be recorded from individual fibers of the relevant minerals, and identifications are made on the basis of semiquantitative comparisons with these reference spectra.

d. Calibration of Grid Openings.

i. Measure 20 grid openings on each of 20 random 200-mesh copper grids by placing a grid on a glass slide and examining it under the PCM. Use a calibrated graticule to measure the average field diameter and use this number to calculate the field area for an average grid opening. Grids are to be randomly selected from batches up to 1,000.

Note: A grid opening is considered as one field.

ii. The mean grid opening area must be measured for the type of specimen grids in use. This can be accomplished on the TEM at a properly calibrated low magnification or on an optical microscope at a magnification of approximately 400X by using an eyepiece fitted with a scale that has been calibrated against a stage micrometer. Optical microscopy utilizing manual or automated procedures may be used providing instrument calibration can be verified.

e. Determination of Camera Constant and ED Pattern Analysis.

i. The camera length of the TEM in ED operating mode must be calibrated before ED patterns on unknown samples are observed. This can be achieved by using a carbon-coated grid on which a thin film of gold has been sputtered or evaporated. A thin film of gold is evaporated on the specimen TEM grid to obtain zone-axis ED patterns superimposed with a ring pattern from the polycrystalline gold film.

ii. In practice, it is desirable to optimize the thickness of the gold film so that only one or two sharp rings are obtained on the superimposed ED pattern. Thicker gold film would normally give multiple gold rings, but it will tend to mask weaker diffraction spots from the unknown fibrous particulates. Since the unknown d-spacings of most interest in asbestos analysis are those which lie closest to the transmitted beam, multiple gold rings are unnecessary on zone-axis ED patterns. An average camera constant using multiple gold rings can be determined. The camera constant is one half the diameter

constant using multiple gold rings can be determined. The camera constant is one-half the diameter, D , of the rings times the interplanar spacing, d , of the ring being measured. K. Quality Control/Quality Assurance Procedures (Data Quality Indicators)

Monitoring the environment for airborne asbestos requires the use of sensitive sampling and analysis procedures. Because the test is sensitive, it may be influenced by a variety of factors. These include the supplies used in the sampling operation, the performance of the sampling, the preparation of the grid from the filter and the actual examination of this grid in the microscope. Each of these unit operations must produce a product of defined quality if the analytical result is to be a reliable and meaningful test result. Accordingly, a series of control checks and reference standards is performed along with the sample analysis as indicators that the materials used are adequate and the operations are within acceptable limits. In this way, the quality of the data is defined and the results are of known value. These checks and tests also provide timely and specific warning of any problems which might develop within the sampling and analysis operations. A description of these quality control/quality assurance procedures is summarized in the following Table III:

TABLE III--SUMMARY OF LABORATORY DATA QUALITY OBJECTIVES

Unit Operation	QC Check	Frequency	Confidence Expectations
Sample receipt	Review of receiving report	Each sample	95% complete
Sample custody	Review of chain of custody record	Each sample	95% complete
Sample preparation	Supplies and reagents	On receipt	Meet specs. or reject
	Grid opening size	20 openings/20 grids for of 1000 or 1 opening/sample	100%
	Special clean room monitoring	After cleaning or service	Meet specs. or reject
	Laboratory blank	2 per prep series or 10%	Meet specs. or transmission, etc.
	Plasma rich blank	1 per 30 samples	75%
Sample analysis	Multiple preps (3 per sample)	Each sample	One with scores of 25 complete grids
	System check	Each day	Each day
	Alignment check	Each day	Each day
	Magnification calibration with low and high standards	Each month or after service	95%
	ED calibration by gold standard	Weekly	95%
Performance check	EDS calibration by copper line	Daily	95%
	Laboratory based measure of cleanliness	Prep 1 per series or 10% read 1 per 25 samples	Meet specs. or transmission, etc.
	Replicate counting (measure of precision)	1 per 400 samples	1.5 x Precision Std. Dev.
	Duplicate analysis (measure of reproducibility)	1 per 200 samples	2 x Precision Std. Dev.
	Known samples of typical materials (working standards)	Training and proficiency persons with unknowns	100%
	Analysis of NBS SRM 1870 and/or RM 8420 (measure of accuracy and comparability)	1 per analysis per year	1.5 x Precision Std. Dev.
	Data entry review (data validation and response of completeness)	Each sample	95%
	Revisit and verify 10 electron diffraction patterns of structure	1 per 5 samples	80% accuracy
	Hand calculation of expected data reduction procedure as independent reevaluation of hand-calculated data	2 per 100 samples	95%
Calibration and data reduction			

1. When the samples arrive at the laboratory, check the samples and documentation for completeness and requirements before initiating the analysis.
2. Check all laboratory reagents and supplies for acceptable asbestos background levels.
3. Conduct all sample preparation in a clean room environment monitored by laboratory blanks and special testing after cleaning or servicing the room.
4. Prepare multiple grids of each sample.
5. Provide laboratory blanks with each sample batch. Maintain a cumulative average of these results.

If this average is greater than 55 μm \pm 2 per 10 200-mesh grid openings, check the system for possible sources of contamination.

6. Check for recovery of asbestos from cellulose ester filters submitted to plasma asher.
7. Check for asbestos carryover in the plasma asher by including a blank alongside the positive control sample.
8. Perform a systems check on the transmission electron microscope daily.
9. Make periodic performance checks of magnification, electron diffraction and energy dispersive X-ray systems as set forth in Table III of Unit III.K.
10. Ensure qualified operator performance by evaluation of replicate counting, duplicate analysis, and standard sample comparisons as set forth in Table III of Unit III.K.
11. Validate all data entries.
12. Recalculate a percentage of all computations and automatic data reduction steps as specified in Table III.
13. Record an electron diffraction pattern of one asbestos structure from every five samples that contain asbestos. Verify the identification of the pattern by measurement or comparison of the pattern with patterns collected from standards under the same conditions. The outline of quality control procedures presented above is viewed as the minimum required to assure that quality data is produced for clearance testing of an asbestos abated area. Additional information may be gained by other control tests. Specifics on those control procedures and options available for environmental testing can be obtained by consulting References 6, 7, and 11 of Unit III.L. L. References

For additional background information on this method the following references should be consulted.

1. "Guidelines for Controlling Asbestos-Containing Materials in Buildings," EPA 560/5-85-024, June 1985.
2. "Measuring Airborne Asbestos Following an Abatement Action," USEP/Office of Pollution Prevention and Toxics, EPA 600/4-85-049, 1985.
3. Small, John and E. Steel. Asbestos Standards: Materials and Analytical Methods. N.B.S. Special Publication 619, 1982.
4. Campbell, W.J., R.L. Blake, L.L. Brown, E.E. Cather, and J.J. Sjoberg. Selected Silicate Minerals and Their Asbestiform Varieties. Information Circular 8751, U.S. Bureau of Mines, 1977.
5. Quality Assurance Handbook for Air Pollution Measurement System. Ambient Air Methods, EPA 600/4-77-027a, USEPA, Office of Research and Development, 1977.
6. Method 2A: Direct Measurement of Gas Volume Through Pipes and Small Ducts. 40 CFR Part 60 Appendix A.

7. Dandekar, C. J. Health & Safety from Asbestos. Research & Tech. Services Div. London. "Dandekar"

7. Burdette, G.J. Health & Safety Exec., Research & Lab. Services Div., London, "Proposed Analytical Method for Determination of Asbestos in Air."

8. Chatfield, E.J., Chatfield Tech. Cons., Ltd., Clark, T., PEI Assoc. "Standard Operating Procedure for Determination of Airborne Asbestos Fibers by Transmission Electron Microscopy Using Polycarbonate Membrane Filters." WERL SOP 87-1, March 5, 1987.

9. NIOSH. Method 7402 for Asbestos Fibers, December 11, 1986 Draft.

10. Yamate, G., S.C. Agarwall, R.D. Gibbons, IIT Research Institute, "Methodology for the Measurement of Airborne Asbestos by Electron Microscopy." Draft report, USEPA Contract 68-02-3266, July 1984.

11. Guidance to the Preparation of Quality Assurance Project Plans. USEPA, Office of Pollution Prevention and Toxics, 1984.

IV. Mandatory Interpretation of Transmission Electron Microscopy Results to Determine Completion of Response Actions

A. Introduction

A response action is determined to be completed by TEM when the abatement area has been cleaned and the airborne asbestos concentration inside the abatement area is no higher than concentrations at locations outside the abatement area. "Outside" means outside the abatement area, but not necessarily outside the building. EPA reasons that an asbestos removal contractor cannot be expected to clean an abatement area to an airborne asbestos concentration that is lower than the concentration of air entering the abatement area from outdoors or from other parts of the building. After the abatement area has passed a thorough visual inspection, and before the outer containment barrier is removed, a minimum of five air samples inside the abatement area and a minimum of five air samples outside the abatement area must be collected. Hence, the response action is determined to be completed when the average airborne asbestos concentration measured inside the abatement area is not statistically different from the average airborne asbestos concentration measured outside the abatement area.

The inside and outside concentrations are compared by the Z-test, a statistical test that takes into account the variability in the measurement process. A minimum of five samples inside the abatement area and five samples outside the abatement area are required to control the false negative error rate, i.e., the probability of declaring the removal complete when, in fact, the air concentration inside the abatement area is significantly higher than outside the abatement area. Additional quality control is provided by requiring three blanks (filters through which no air has been drawn) to be analyzed to check for unusually high filter contamination that would distort the test results.

When volumes greater than or equal to 1,199 L for a 25 mm filter and 2,799 L for a 37 mm filter have been collected and the average number of asbestos structures on samples inside the abatement area is no greater than 70 s/mm² of filter, the response action may be considered complete without comparing the inside samples to the outside samples. EPA is permitting this initial screening test to save analysis costs in situations where the airborne asbestos concentration is sufficiently low so that it cannot be distinguished from the filter contamination/background level (fibers deposited on the filter that are unrelated to the air being sampled). The screening test cannot be used when volumes of less than 1,199 L for 25 mm filter or 2,799 L for a 37 mm filter are collected because the ability to distinguish levels significantly different from filter background is

collected because the ability to distinguish levels significantly different from filter background is reduced at low volumes.

The initial screening test is expressed in structures per square millimeter of filter because filter background levels come from sources other than the air being sampled and cannot be meaningfully expressed as a concentration per cubic centimeter of air. The value of 70 s/mm² is based on the experience of the panel of microscopists who consider one structure in 10 grid openings (each grid opening with an area of 0.0057 mm²) to be comparable with contamination/background levels of blank filters. The decision is based, in part, on Poisson statistics which indicate that four structures must be counted on a filter before the fiber count is statistically distinguishable from the count for one structure. As more information on the performance of the method is collected, this criterion may be modified. Since different combinations of the number and size of grid openings are permitted under the TEM protocol, the criterion is expressed in structures per square millimeter of filter to be consistent across all combinations. Four structures per 10 grid openings corresponds to approximately 70 s/mm². B. Sample Collection and Analysis

1. A minimum of 13 samples is required: five samples collected inside the abatement area, five samples collected outside the abatement area, two field blanks, and one sealed blank.

2. Sampling and TEM analysis must be done according to either the mandatory or nonmandatory protocols in Appendix A. At least 0.057 mm² of filter must be examined on blank filters. C. Interpretation of Results

1. The response action shall be considered complete if either:

a. Each sample collected inside the abatement area consists of at least 1,199 L of air for a 25 mm filter, or 2,799 L of air for a 37 mm filter, and the arithmetic mean of their asbestos structure concentrations per square millimeter of filter is less than or equal to 70 s/mm²; or

b. The three blank samples have an arithmetic mean of the asbestos structure concentration on the blank filters that is less than or equal to 70 s/mm² and the average airborne asbestos concentration measured inside the abatement area is not statistically higher than the average airborne asbestos concentration measured outside the abatement area as determined by the Z-test. The Z-test is carried out by calculating

$$Z = \frac{\bar{Y}_I - \bar{Y}_O}{0.8(\sqrt{n_I} + \sqrt{n_O})^{1/2}}$$

where \bar{Y}_I is the average of the natural logarithms of the inside samples and \bar{Y}_O is the average of the natural logarithms of the outside samples, n_I is the number of inside samples and n_O is the number of outside samples. The response action is considered complete if Z is less than or equal to 1.65.

Note: When no fibers are counted, the calculated detection limit for that analysis is inserted for the concentration.

2. If the abatement site does not satisfy either (1) or (2) of this Section C, the site must be recleaned and a new set of samples collected. D. Sequence for Analyzing Samples

It is possible to determine completion of the response action without analyzing all samples. Also, at any point in the process, a decision may be made to terminate the analysis of existing samples

any point in the process, a decision may be made to terminate the analysis of existing samples, reclean the abatement site, and collect a new set of samples. The following sequence is outlined to minimize the number of analyses needed to reach a decision.

1. Analyze the inside samples.
2. If at least 1,199 L of air for a 25 mm filter or 2,799 L of air for a 37 mm filter is collected for each inside sample and the arithmetic mean concentration of structures per square millimeter of filter is less than or equal to 70 s/mm², the response action is complete and no further analysis is needed.
3. If less than 1,199 L of air for a 25 mm filter or 2,799 L of air for a 37 mm filter is collected for any of the inside samples, or the arithmetic mean concentration of structures per square millimeter of filter is greater than 70 s/mm², analyze the three blanks.
4. If the arithmetic mean concentration of structures per square millimeter on the blank filters is greater than 70 s/mm², terminate the analysis, identify and correct the source of blank contamination, and collect a new set of samples.
5. If the arithmetic mean concentration of structures per square millimeter on the blank filters is less than or equal to 70 s/mm², analyze the outside samples and perform the Z-test.
6. If the Z-statistic is less than or equal to 1.65, the response action is complete. If the Z-statistic is greater than 1.65, reclean the abatement site and collect a new set of samples.

[52 FR 41857, Oct. 30, 1987]



Appendix E
Libby Montana Field Sample Data Sheets

LIBBY MONTANA FIELD SAMPLE DATA SHEET

STATIONARY AIR

Scenario No.: _____ Field Logbook No: _____ Page No: _____ Sampling Date: _____

Address: _____ Owner/Tenant: _____

Land Use: Residential School Commercial Mining Roadway Other ()

Sampling Team: PES CDM Other _____ Names: _____

Data Item	Cassette 1	Cassette 2	Cassette 3
Index ID			
Location ID			
Sample Group			
Location Description			
Category (circle)	FS Blank Rep _____	FS Blank Rep _____	FS Blank Rep _____
Matrix Type (circle)	Indoor Outdoor NA	Indoor Outdoor NA	Indoor Outdoor NA
Filter Diameter (circle)	25mm 37mm	25mm 37mm	25mm 37mm
Pore Size (circle)	TEM- .45 PCM- 0.8	TEM- .45 PCM- 0.8	TEM- .45 PCM- 0.8
Flow Meter Type (circle)	Rotometer DryCal	Rotometer DryCal	Rotometer DryCal
Pump ID Number			
Flow Meter ID No.			
Start Date			
Start Time			
Start Flow (L/min)			
Stop Date			
Stop Time			
Stop Flow (L/min)			
Pump fault? (circle)	No Yes	No Yes	No Yes
MET Station onsite?	No Yes	No Yes	No Yes
Pre/Post (circle)	Pre Post Clear NA	Pre Post Clear NA	Pre Post Clear NA
Field Comments			
	Entered ____ Validated ____	Entered ____ Validated ____	Entered ____ Validated ____

LIBBY MONTANA FIELD SAMPLE DATA SHEET

PERSONAL AIR

Scenario No.: _____ Field Logbook No: _____ Page No: _____ Sampling Date: _____

Address: _____ Owner/Tenant: _____

Sampling Team: MACTEC CDM Other _____ Names: _____

Land Use: Residential School Commercial Mining Roadway Other ()

Person Sampled: _____ SSN: _____ Task: _____

Data Item	Cassette 1	Cassette 2	Cassette 3
Index ID			
Location ID			
Sample Group			
Location Description			
Category (circle)	FS Blank Rep _____	FS Blank Rep _____	FS Blank Rep _____
Matrix Type (circle)	Indoor Outdoor NA	Indoor Outdoor NA	Indoor Outdoor NA
Filter Diameter (circle)	25mm 37mm	25mm 37mm	25mm 37mm
Pore Size (circle)	TEM- .45 PCM- 0.8	TEM- .45 PCM- 0.8	TEM- .45 PCM- 0.8
Flow Meter Type (circle)	Rotometer DryCal	Rotometer DryCal	Rotometer DryCal
Pump ID Number			
Flow Meter ID No.			
Start Date			
Start Time			
Start Flow (L/min)			
Stop Date			
Stop Time			
Stop Flow (L/min)			
Pump fault?	No Yes	No Yes	No Yes
MET Station onsite?	No Yes	No Yes	No Yes
Sample Type	TWA EXC NA	TWA EXC NA	TWA EXC NA
Field Comments			
	Entered ___ Validated ___	Entered ___ Validated ___	Entered ___ Validated ___

LIBBY MONTANA FIELD SAMPLE DATA SHEET**WATER/SEDIMENT**

Scenario No.: _____ Field Logbook No: _____ Page No: _____ Sampling Date: _____

Address: _____ Owner/Tenant: _____

Land Use: Residential School Commercial Mining Roadway Other ()

Sampling Team: MACTEC CDM Other _____ Names: _____

Data Item	Sample 1	Sample 2	Sample 3
Index ID			
Location ID			
Sample Group			
Location Description			
Category (circle)	FS _____ Trip Blank FD _____	FS _____ Trip Blank FD _____	FS _____ Trip Blank FD _____
Matrix Type (circle)	Surface Water Well Water Laboratory Water Sediment Other _____	Surface Water Well Water Laboratory Water Sediment Other _____	Surface Water Well Water Laboratory Water Sediment Other _____
Field Comments			
	Entered ____ Validated ____	Entered ____ Validated ____	Entered ____ Validated ____

Appendix F
CDM Federal Standard Operating Procedures
(SOPs)

SAMPLE CUSTODY

SOP 1-2

Revision: 3

Date October 12, 2001

Page 1 of 9

Prepared: David O. Johnson

Technical Review: Jackie Mosher

QA Review: Doug Updike

Approved: [Signature]

Issued: Rose Mary Gustin 10/12/01
Signature/Date

Signature/Date

1.0 OBJECTIVE

Due to the evidentiary nature of samples collected during environmental investigations, possession must be traceable from the time the samples are collected until their derived data are introduced as evidence in legal proceedings. To maintain and document sample possession, sample custody procedures are followed. All paperwork associated with the sample custody procedures will be retained in CDM Federal Programs Corporation (CDM Federal) files unless the client requests that it be transferred to them for use in legal proceedings or at the completion of the contract.

Note: Sample custody documentation requirements vary with the specific EPA region or client. This SOP is intended to present basic sample custody requirements, along with common options. Specific sample custody requirements should be presented in the project-specific quality assurance (QA) project plan or project-specific modification or clarification form (See Section U-1).

2.0 BACKGROUND

2.1 Definitions

Sample – A sample is material to be analyzed that is contained in single or multiple containers representing a unique sample identification number.

Sample Custody – A sample is under custody if:

1. It is in your possession.
2. It is in your view, after being in your possession.
3. It was in your possession and you locked it up.
4. It is in a designated secure area.

Chain-of-Custody Record – A chain-of-custody record is a form used to document the transfer of custody of samples from one individual to another.

Custody Seal - A custody seal is a tape-like seal that is part of the chain-of-custody process and is used to detect tampering with samples after they have been packed for shipping.

SAMPLE CUSTODY

SOP 1-2

Revision: 3

Date October 12, 2001

Page 2 of 9

Sample Label – A sample label is an adhesive label placed on sample containers to designate a sample identification number and other sampling information.

Sample Tag – A sample tag is attached with string to a sample container to designate a sample identification number and other sampling information. Tags may be used when it is difficult to physically place adhesive labels on the container (e.g., in the case of small air sampling tubes).

3.0 RESPONSIBILITIES

Sampler – The sampler is personally responsible for the care and custody of the samples collected until they are properly transferred or dispatched.

Field Team Leader (FTL) – The FTL is responsible for ensuring that strict chain-of-custody procedures are maintained during all sampling events. The FTL is also responsible for coordinating with the subcontractor laboratory to ensure that adequate information is recorded on custody records. The FTL determines whether proper custody procedures were followed during the fieldwork and decides if additional samples are required.

Field Sample Custodian – The field sample custodian, when designated by the FTL, is responsible for accepting custody of samples from the sampler(s) and properly packing and shipping the samples to the laboratory assigned to do the analyses. A field sample custodian is typically designated only for large and complex field efforts.

4.0 REQUIRED SUPPLIES

- Chain-of-custody records (applicable client or CDM Federal forms)
- Custody seals
- Sample labels or tags
- Clear tape

5.0 PROCEDURES

5.1 Chain-of-Custody Record

This procedure establishes a method for maintaining custody of samples through use of a chain-of-custody record. This procedure will be followed for all samples collected or split samples accepted.

SAMPLE CUSTODY

SOP 1-2

Revision: 3

Date October 12, 2001

Page 3 of 9

Field Custody

1. Collect only the number of samples needed to represent the media being sampled. To the extent possible, determine the quantity and types of samples and sample locations prior to the actual fieldwork. As few people as possible should handle samples.
2. Complete sample labels or tags for each sample, using waterproof ink.

Transfer of Custody and Shipment

1. Complete a chain-of-custody record for all samples (see Figure 1 for an example of a chain-of-custody record. Similar forms may be used when requested by the client). When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the record. This record documents sample custody transfer from the sampler, often through another person, to the sample custodian in the appropriate laboratory.
 - The date/time will be the same for both signatures when custody is transferred directly to another person. When samples are shipped via common carrier (e.g., Federal Express), the date/time will not be the same for both signatures. Common carriers are not required to sign the chain-of-custody record.
 - In all cases, it must be readily apparent that the person who received custody is the same person who relinquished custody to the next custodian.
 - If samples are left unattended or a person refuses to sign, this must be documented and explained on the chain-of-custody record.

NOTE: If a field sample custodian has been designated, he/she may initiate the chain-of-custody record, sign and date as the relinquisher. The individual sampler(s) must sign in the appropriate block, but does (do) not need to sign and date as a relinquisher (refer to Figure 1).

2. Package samples properly for shipment and dispatch to the appropriate laboratory for analysis. Each shipment must be accompanied with a separate chain-of-custody record.
3. Include a chain-of-custody record identifying its content in all shipments (refer to Figure 1). The original record will accompany the shipment, and the copies will be retained by the FTL and, if applicable, distributed to the appropriate sample coordinators. Freight bills will also be retained by the FTL as part of the permanent documentation.

SOP 1-2

Revision: 3

Date October 12, 2001

Page 4 of 9

Figure 1
EXAMPLE CDM Federal Chain-of-Custody Record

CDM Federal Programs Corporation
A subsidiary of Camp Dresser & McKee Inc.

125 Maiden Lane, 5th Floor
New York, NY 10038
(212) 785-9123
Fax: (212) 785-6114

CHAIN OF CUSTODY RECORD

PROJECT ID.		FIELD TEAM LEADER		LABORATORY AND ADDRESS						DATE SHIPPED						
PROJECT NAME/LOCATION				LAB CONTRACT:								AIRBILL NO.				
MEDIA TYPE 1. Surface Water 2. Groundwater 3. Leachate 4. Field QC 5. Soil/Sediment 6. Oil 7. Waste 8. Other _____		PRESERVATIVES 1. HCl, pH <2 2. HNO ₃ , pH <2 3. NaOH, pH >12 4. H ₂ SO ₄ , pH <2 5. Zinc Acetate, pH >9 6. Ice Only 7. Not Preserved 8. Other _____		SAMPLE TYPE G = Grab C = Composite		ANALYSES (List no. of containers submitted)										
SAMPLE LOCATION NO.	LABORATORY SAMPLE NUMBER	PRESERVATIVES ADDED	MEDIA TYPE	SAMPLE TYPE	19__ DATE			TIME SAMPLED								
1.																
2.																
3.																
4.																
5.																
6.																
7.																
8.																
9.																
10.																
SAMPLER SIGNATURES:																
RELINQUISHED BY: (PRINT)	DATE/TIME	RECEIVED BY: (PRINT)	DATE/TIME	RELINQUISHED BY: (PRINT)	DATE/TIME	RECEIVED BY: (PRINT)	DATE/TIME									
(SIGN)		(SIGN)		(SIGN)		(SIGN)										
RELINQUISHED BY: (PRINT)	DATE/TIME	RECEIVED BY: (PRINT)	DATE/TIME	RELINQUISHED BY: (PRINT)	DATE/TIME	RECEIVED BY: (PRINT)	DATE/TIME									
(SIGN)		(SIGN)		(SIGN)		(SIGN)										
COMMENTS:																

DISTRIBUTION: White and yellow copies accompany sample shipment to laboratory; yellow copy retained by laboratory. Pink copy retained by samplers.

1/98

NOTE: If requested by the client, different chain-of-custody records may be used. Copies of the template for this record may be obtained from the Fairfax Graphics Department.

SAMPLE CUSTODY

SOP 1-2

Revision: 3

Date October 12, 2001

Page 5 of 9

Procedure for Completing CDM Federal Example Chain-of-Custody Record (Refer to Figure 1.)

The following procedure is to be used to fill out the CDM Federal chain-of-custody record. The record is provided herein as an example chain-of-custody record. If another type of custody record (i.e., provided by the EPA contract laboratory program or a subcontract laboratory) is used to track the custody of samples, the custody record should be filled out in its entirety.

1. Record project number.
2. Record FTL for the project (if a field sample custodian has been designated, also record this name in the "Remarks" box).
3. Record the name and address of the laboratory to which samples are being shipped.
4. Enter the project name/location or code number.
5. Record overnight courier's airbill number.
6. Record sample location number.
7. Record sample number.
8. Note preservatives type and reference number.
9. *Note media type (matrix) and reference number.*
10. Note sample type.
11. Enter date of sample collection.
12. Enter time of sample collection in military time.
13. When required by the client, enter the names or initials of the samplers next to the sample location number of the sample they collected.
14. List parameters for analysis and the number of containers submitted for each analysis.
15. Enter MS/MSD (matrix spike/matrix spike duplicate) if sample is for laboratory quality control or other remarks (e.g. sample depth).
16. Sign the chain-of-custody record(s) in the space provided. All samplers must sign each record.
17. If sample tags are used, record the sample tag number in the "Remarks" column.
18. Record date shipped.
19. The originator checks information entered in Items 1 through 16 and then signs the top left "Relinquished by" box, prints his/her name, and enters the current date and time (military).

SAMPLE CUSTODY

SOP 1-2

Revision: 3

Date October 12, 2001

Page 6 of 9

20. Send the top two copies (usually white and yellow) with the samples to the laboratory; retain the third copy (usually pink) for the project files. Retain additional copies for the project file or distribute as required to the appropriate sample coordinators.
21. The laboratory sample custodian receiving the sample shipment checks the sample label information against the chain-of-custody record. Sample condition is checked and anything unusual is noted under "Remarks" on the chain-of-custody record. The laboratory custodian receiving custody signs in the adjacent "Received by" box and keeps the copy. The white copy is returned to CDM Federal.

5.2 Sample Labels and Tags

Unless the client directs otherwise, sample labels or tags will be used for all samples collected or accepted for CDM Federal projects.

1. Complete one label or tag with the information required by the client for each sample container collected. A typical label or tag would be completed as follows (see Figure 2 for example of sample tag; labels are completed with the equivalent information):
 - Record the project code (i.e., project or task number).
 - Enter the station number (sample number) if applicable.
 - Record the date to indicate the month, day, and year of sample collection.
 - Enter the time (military) of sample collection.
 - Place a check to indicate composite or grab sample.
 - Record the station (sample) location.
 - Sign in the space provided.
 - Place a check next to "yes" or "no" to indicate if a preservative was added.
 - Place a check under "Analyses" next to the parameters for which the sample is to be analyzed. If the desired analysis is not listed, write it in the empty slot. Note: Do not write in the box for "laboratory sample number."
 - Place or write additional relevant information under "Remarks".
2. Place adhesive labels directly on the sample containers. Place clear tape over the label to protect from moisture.
3. Securely attach sample tags to the sample bottle. On 80 oz. amber bottles, the tag string may be looped through the ring style handle and tied. On all other containers, it is recommended that the string be looped around the neck of the bottle, then twisted and re-looped around the neck until the slack in the string is removed.

SAMPLE CUSTODY

SOP 1-2

Revision: 3

Date October 12, 2001

Page 7 of 9

Figure 2
EXAMPLE Sample Tag

Designation		Grab	Comp.	Time	Month/Day/Year	Station No.	Project Code	Station Location	Preservative:		
									Yes <input type="checkbox"/>	No <input type="checkbox"/>	
Sample Signature									ANALYSES		
									BOD	Anions	
Sample Signature									Solids	(mg/L) (mg/L) (ppm)	
									COD, TOC, Nutrients		
Sample Signature									Phenolics		
									Mercury		
Sample Signature									Metals		
									Cyanide		
Sample Signature									Oil and Grease		
									Organics GC/MS		
Sample Signature									Priority Pollutants		
									Volatile Organics		
Sample Signature									Pesticides		
									Mutagenicity		
Sample Signature									Bacteriology		
Sample Signature									Remarks:		
Tag No.									Lab Sample No.		
3-3023215											

NOTE: Equivalent sample labels or tags may be used.

SAMPLE CUSTODY

SOP 1-2

Revision: 3

Date October 12, 2001

Page 8 of 9

5.3 Custody Seals

Custody seals must be placed on the shipping containers (e.g., picnic cooler) prior to shipment. The seal should be signed and dated by a field team member.

Custody seals may also be placed on individual sample bottles. Check with the client or refer to EPA regional guidelines for direction.

5.4 Sample Shipping

The CDM Federal standard operating procedure listed below defines the requirements for packaging and shipping environmental samples.

- CDM Federal SOP 2-1, Packaging and Shipping of Environmental Samples

6.0 RESTRICTIONS/LIMITATIONS

Check with the EPA region or client for specific guidelines. If no specific guidelines are identified, this procedure should be followed.

For EPA Contract Laboratory Program (CLP) sampling events, combined chain-of-custody/traffic report forms or other EPA-specific records may be used. Refer to regional guidelines for completing these forms.

The EPA FORMS II Lite™ software may be used to customize sample labels and custody records when directed by the client or the CDM Federal project manager.

SAMPLE CUSTODY

SOP 1-2

Revision: 3

Date October 12, 2001

Page 9 of 9

7.0 REFERENCES

U.S. Environmental Protection Agency, *EPA Guidance for Quality Assurance Project Plans*, EPA QA/G-5, EPA/600/R-98/018, February 1998, Section B3.

U.S. Environmental Protection Agency, *National Enforcement Investigations Center, Multi-Media Investigation Manual*, EPA-330/9-89-003-R, Revised March 1992, p.85.

U.S. Environmental Protection Agency, *Contract Laboratory Program (CLP), Guidance for Field Samplers*, EPA-540-R-00-003, Draft Final, June 2001, Section 3.2.

U.S. Environmental Protection Agency, *FORMS II Lite™ User's Guide*, March 2001

U.S. Environmental Protection Agency, Region IV, *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual*, May 1996, Section 3.3.

U.S. Army Corps of Engineers, *Requirements for the Preparation of Sampling and Analysis Plan*, EM 200-1-3, February 2001, Appendix F.

GROUNDWATER SAMPLING USING BAILERS

SOP: 1-5

Revision: 4

Date: December 11, 2002

Page: 1 of 5

Prepared: Del Baird

Technical Review: Del Baird

QA Review: Krista Lippoldt

Approved: [Signature] 12/18/02

Issued: [Signature] 12/18/02
Signature/Date

Signature/Date

1.0 OBJECTIVE

The purpose of this standard operating procedure (SOP) is to define requirements for the collection of groundwater samples with bailers.

2.0 BACKGROUND

Collection of groundwater samples from monitoring wells on or near a hazardous waste site may be required to characterize the nature and extent of contamination.

Methods used for the collection of groundwater samples include bailing and a variety of pumping techniques. Bailers are hollow cylinders with unidirectional (open up) check valves at the bottom end. Some bailers may also be closed or valved at the upper end. Bailers used in environmental applications are typically constructed of PVC, stainless steel, or Teflon®. The bailer cable typically consists of disposable nylon cord, disposable polypropylene cord, or Teflon®-coated stainless steel wire line. The bailer is lowered into the well on an acceptable line until submerged. The bailer is then retrieved to the surface for sample collection. For the best results, the sequence of sampling is from least to most contaminated wells. It is preferable to have bailers dedicated to each monitoring well.

2.1 Associated Procedures

- CDM Federal (CDM) SOP 1-2, Sample Custody
- CDM SOP 1-6, Water Level Measurement
- CDM SOPs 2-1 through 2-5, Packaging and Shipping of Environmental Samples (with different field preservatives)
- CDM SOP 2-6, Packaging and Shipping of Radioactive Materials in Limited Quantities
- CDM SOP 4-1, Field Logbook Content and Control
- CDM SOP 4-3, Well Development and Purging
- CDM SOP 4-5, Field Equipment Decontamination at Non-radioactive Sites

3.0 RESPONSIBILITIES

Site Manager - The Site Manager is responsible for ensuring that field personnel are trained in the use of this procedure and for verifying that groundwater samples are collected in accordance with this procedure.

GROUNDWATER SAMPLING USING BAILERS

SOP: 1-5

Revision: 4

Date: December 11, 2002

Page: 2 of 5

Field Team Leader - The Field Team Leader is responsible for ensuring that sampling efforts are conducted in accordance with this procedure, and any associated SOPs.

4.0 REQUIRED EQUIPMENT

- Site-specific plans
- Field logbook
- Indelible black ink pens and markers
- Labels and appropriate forms/documentation for sample shipment
- Insulated cooler and waterproof sealing tape (strapping tape)
- Plastic zip-top bags
- Ice bags or "blue ice"
- Bailer of the appropriate design and construction for the sampling application
- Clean cord or wire line of sufficient length for conditions
- Water-level meter and/or other water-level measuring device
- Clean beaker(s) or other container for measurement of water quality parameters
- Plastic sheeting (4 ml thickness)
- Latex or appropriate gloves
- Filtering apparatus, if required
- Appropriate sample containers with labels and preservatives, as required
- Temperature, conductivity, pH, dissolved oxygen, and turbidity meters as required by the site-specific plans
- Photo ionization detector (PID) or equivalent and other instruments as required by the site-specific health and safety plan
- Decontamination supplies, as required by CDM SOP 4-5
- Personal protective clothing and equipment, if required by the site-specific health and safety plan

5.0 PROCEDURES

1. Don personal protective clothing and equipment as specified in the site-specific health and safety plan. All field equipment will be calibrated, tested, or checked for proper functioning before use as per the manufacturer's instructions.
2. Prepare the site for sample acquisition. If required cover the ground surface around the wellhead with plastic sheeting. Arrange the required decontaminated sampling and monitoring equipment for convenient use. If on-site decontamination is required, arrange the necessary supplies in a nearby but separate location, away from the wellhead (e.g., exclusion zone).
3. Open the well and note the condition of the casing and cap. Immediately check for organic vapors using a PID or FID as appropriate. Refer to the site health and safety plan for the required monitoring and frequencies.

GROUNDWATER SAMPLING USING BAILERS

SOP: 1-5

Revision: 4

Date: December 11, 2002

Page: 3 of 5

4. Determine the static water level and depth to well bottom according to CDM SOP 1-6. Record this information in the field logbook or on the appropriate form.
5. Purge the well according to CDM SOP 4-3,
6. Securely attach the bailer to the line. The opposite end of the line should be secured to prevent loss of the bailer into the well.
7. Arrange the sample containers in the order of use. Samples for volatile constituents, if required, shall be obtained first, followed in order by other organic samples, then inorganic samples and other parameters. For example:

a) Volatile organic compounds (VOC)	g) Total metals
b) Purgeable organic carbon (POC)	h) Dissolved metals
c) Purgeable organic halogens (POX)	i) Cyanide
d) Total organic halogens (TOX)	j) Sulfate and chloride
e) Total organic carbon (TOC)	k) Nitrate and ammonia
f) Extractable organics	l) Radionuclides

Note: (i) Allow the water level to recover to a depth at least sufficient for the complete submergence of the bailer without contacting the well bottom. (The water level in the well should be allowed to recharge 75 percent of its static level so that a representative sample of the screened portion of the aquifer can be obtained.) Samples shall be collected within 3 hours of purging if recharge is sufficient. Wells with a low recharge rate must be collected within 24 hours of purging. (ii) Extractables include semi-volatile organic compounds, pesticides and PCBs.

8. Don clean sampling gloves; lower the decontaminated or certified pre-cleaned bailer into the well. The bailer should enter the water slowly to prevent aeration, particularly when volatile constituent samples are being collected. Care should be taken to avoid having the bailer come in contact with the well bottom.
9. Retrieve the filled bailer to the surface. In order to prevent contamination of the bailer line, do not allow line to contact the ground or keep line on plastic sheeting. Hang the bailer from a bailer stand or other support, if available, or have an assistant hold it off the ground. Immediately obtain any required volatile samples (VOC, POC, POX, TOX, TOC) gently transferring water to the sample bottle. The containers for organic analytes should be tilted when filling to prevent aeration. Check the filled VOC vials for bubbles. If bubbles are present in a vial, discard it and fill another vial from the bailer. After collecting volatile samples, lower the bailer to collect additional water for the remaining parameters. If sample filtration is required for metals, it should be performed immediately following sample retrieval, and prior to sample preservation. Organic samples generally do not require filtration; VOC samples should never be

GROUNDWATER SAMPLING USING BAILERS

SOP: 1-5

Revision: 4

Date: December 11, 2002

Page: 4 of 5

filtered. Preservation of samples should be performed according to the applicable field plan. Check the pH on samples that require preservation.

10. Wipe the outer surfaces of the sample containers clean with a Kim-wipe or clean paper towel. Additional sample bottle decontamination may be appropriate in some cases.
11. Properly label all containers according to the appropriate Packaging and Shipping SOP.
12. Place sample containers in individual zip-top plastic bags, and seal the bags (if required by site-specific plans).
13. Immediately pack all sample containers that require a 4°C preservation on ice (or "blue ice") in coolers (refer to the sampling plans).
14. Record analytes and volumes collected, and time and date of collection in the field logbook. Prepare chain-of-custody forms according to site-specific plans and CDM SOP 1-2.
15. Decontaminate sampling equipment according to CDM SOP 4-5.
16. Close and lock the well cover. Clean up the area and place disposable materials (plastic sheeting, gloves, Tyvek) in the designated receptacle.

6.0 RESTRICTIONS/LIMITATIONS

Obtain required field measurements such as temperature, conductivity, pH, oxidation potential (Eh), turbidity, salinity, or dissolved oxygen measurements immediately after samples have been collected. This may require additional time for well recovery.

Note: Some of these parameters will have already been determined during purging; they should be repeated after sample collection if required by site-specific plans.

Careful sampling for VOC analysis or for analysis of any other compound(s) that may be degraded by aeration is necessary to minimize sample disturbance and, hence, analyte loss. The representativeness of this sample, however, is difficult to determine because the collected sample represents a single point, is not homogenized, and has been disturbed.

7.0 REFERENCES

U.S. Department of Energy, Hazardous Waste Remedial Actions Program, *Quality Control Requirements for Field Methods*, DOE/HWP-69R2, September 1996.

U.S. Department of Energy, Hazardous Waste Remedial Actions Program, *Standard Operating Procedures For Site Characterization*, DOE/HWP-100/R1, September 1996.

GROUNDWATER SAMPLING USING BAILERS

SOP: 1-5

Revision: 4

Date: December 11, 2002

Page: 5 of 5

Office of Solid Waste and Emergency Response, RCRA *Groundwater Monitoring Technical Guidance Enforcement Document*, OSWER-9950.1, September 1986.

WATER LEVEL MEASUREMENT

SOP: 1-6

Revision: 4

Date: December 11, 2002

Page: 1 of 9

Prepared: Del Baird

Technical Review: Tammy Phillips

QA Review: Krista Lippoldt

Approved: [Signature] 12/18/02

Signature/Date

Issued: [Signature] 12/18/02

Signature/Date

1.0 OBJECTIVE

Water-level measurements are fundamental to groundwater and solute transport studies and are conducted during groundwater sampling events to calculate purging requirements. This standard operating procedure (SOP) defines the techniques and requirements for taking groundwater level measurements.

2.0 BACKGROUND

2.1 Definitions

Water Level Indicator - A portable device for measuring the depth from a fixed point at the ground surface or above the ground surface to the groundwater inside a well, borehole or other underground opening.

Measurement Point - An easily located and clearly defined mark at the top of a well or borehole from which all water level measurements from that particular well are made. The measurement point should be as permanent as possible to provide consistency in measurements.

Electrical Tape - A graduated plastic tape onto which a water-sensitive electrode is connected that will electronically signal the presence of water (circuit closure).

Immiscible Fluids - Two or more fluid substances that will not mix and, therefore, will exist together in a layered form. The fluid with the highest density will exist as the bottom layer, the fluid with the lowest density will exist as the top layer, and any other fluid layers will be distributed relative to their respective densities.

Discharge - The removal/release of water from the zone of saturation.

Recharge - The addition of water to the zone of saturation.

WATER LEVEL MEASUREMENT

SOP: 1-6

Revision: 4

Date: December 11, 2002

Page: 1 of 9

Prepared: Del Baird

Technical Review: Tammy Phillips

QA Review: Krista Lippoldt

Approved: [Signature]

Signature/Date

12/18/02

Issued: [Signature]

Signature/Date

12/10/02

1.0 OBJECTIVE

Water-level measurements are fundamental to groundwater and solute transport studies and are conducted during groundwater sampling events to calculate purging requirements. This standard operating procedure (SOP) defines the techniques and requirements for taking groundwater level measurements.

2.0 BACKGROUND

2.1 Definitions

Water Level Indicator - A portable device for measuring the depth from a fixed point at the ground surface or above the ground surface to the groundwater inside a well, borehole or other underground opening.

Measurement Point - An easily located and clearly defined mark at the top of a well or borehole from which all water level measurements from that particular well are made. The measurement point should be as permanent as possible to provide consistency in measurements.

Electrical Tape - A graduated plastic tape onto which a water-sensitive electrode is connected that will electronically signal the presence of water (circuit closure).

Immiscible Fluids - Two or more fluid substances that will not mix and, therefore, will exist together in a layered form. The fluid with the highest density will exist as the bottom layer, the fluid with the lowest density will exist as the top layer, and any other fluid layers will be distributed relative to their respective densities.

Discharge - The removal/release of water from the zone of saturation.

Recharge - The addition of water to the zone of saturation.

WATER LEVEL MEASUREMENT

SOP: 1-6

Revision: 4

Date: December 11, 2002

Page: 2 of 9

Static Water Level - The level of water in a well, borehole or other underground opening that is not influenced by discharge or recharge.

Well Riser - A steel, stainless steel, or polyvinyl chloride (PVC) pipe that extends into a borehole and is connected to the well screen or sealed at the bedrock surface in open-hole wells. The well riser is normally enclosed by an outer steel protective casing.

Protective Casing - A steel cylinder or square protective sleeve extending approximately 3 to 5 feet into the ground, surrounding the well riser, and extending above the ground surface approximately 2 to 3 feet. The protective casing protects the well riser.

2.2 Discussion

Major uses of static water level data are to determine the direction of groundwater flow, to identify areas of recharge and discharge, to evaluate the effects of manmade and natural stresses on the groundwater system, to define the hydraulic characteristics of aquifers, and to evaluate stream-aquifer relations. Specific uses for water level data may include:

1. Determine the change in water level due to distribution or rate of regional groundwater withdrawal.
2. Show the relationship of groundwater to surface water.
3. Estimate the amount, source, and area of recharge and discharge.
4. Determine rate and direction of groundwater movement.

Water levels should be measured in each well prior to purging, sampling, or other disturbance of the water table.

2.3 Associated Procedures

- CDM Federal (CDM) SOP 4-1, Field Logbook Content and Control
- CDM SOP 4-5, Field Equipment Decontamination at Non-radioactive Sites

3.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that measurements are conducted in accordance with this procedure and any other SOP pertaining to site activities related to obtaining groundwater level measurements.

WATER LEVEL MEASUREMENT

SOP: 1-6

Revision: 4

Date: December 11, 2002

Page: 3 of 9

Field Team Leader - The Field Team Leader is responsible for ensuring that field personnel take water level measurements in accordance with this and other relevant procedures.

4.0 REQUIRED EQUIPMENT

4.1 General

- Site-specific plans
- Field logbook
- Indelible black ink pens
- Permanent felt-tip marker (e.g., Sharpie)
- Decontamination equipment and supplies, including rinse bottles and de-ionized water
- Personal protective clothing and equipment
- Tap water and large beaker or bucket
- Water level meters

4.2 Measuring Devices

The equipment required to obtain water level measurements is dependent on the type of procedure chosen. Measurements may be made with a number of different devices and procedures. Measurements are taken relevant to a permanent measurement point on the well riser.

When a choice exists, electrical tapes are preferred over other devices such as steel tape due to the electrical tape's simplicity and ability to make measurements in a short period of time. Many types of electrical instruments have been devised for measuring water levels; most operate on the principle that a circuit is completed when two electrodes are immersed in water. Examples of electrical tapes that are frequently used include the Slope Indicator Co.® and Solinst® electronic water level indicators. These instruments are powered by batteries that should be checked prior to mobilization to the field.

Electrical tapes are coiled on a hand-cranked reel unit that contains batteries and a signaling device that indicates when the circuit is closed (i.e., when the probe reaches the water). Electrodes are generally contained in a weighted probe that keeps the tape taut in addition to providing some shielding of the electrodes against false indications as the probe is being lowered into the hole. The electrical tapes are marked with 0.01-foot increments. Caution should be exercised when using electrical tapes when the water contains elevated amounts of dissolved solids. Under these conditions, the signaling device will remain activated after the probe is removed from the water. When the water being measured contains very low amounts of dissolved solids, it is possible for the probe to extend several inches below the water level prior to activating the signaling device. Both of these conditions are related to the conductivity of the water and in some cases may be compensated for by the sensitivity control, if the device has this option.

WATER LEVEL MEASUREMENT

SOP: 1-6

Revision: 4

Date: December 11, 2002

Page: 4 of 9

Steel surveying tapes in lengths of 100, 200, and 300 feet (as appropriate for site geology) are coiled on a hand-cranked reel. They are weighted at the free end to ensure straight-line measurements are made. The lower few feet of tape are chalked by pulling the tape across a piece of carpenter's chalk. After the tape is lowered to the water level and retrieved, the wet chalk mark identifies the portion of the tape that was submerged. This distance is subtracted from the measurement taken at the top of the well (the measurement point). This method of obtaining water level measurements is not recommended for use in monitoring wells where the introduction of chalk into the well may affect the integrity of groundwater samples. The tape used should be capable of being read to 0.01-foot increments. Steel surveying tapes may be used when conditions prohibit the use of other devices. If a steel surveying tape is used, the following items of caution should be noted:

- The steel tape has tremendous tensile strength but will snap very easily when kinked.
- The steel tape has more surface area than round cables and may stick to the sides of casing or boreholes.
- Deep water levels may be difficult to measure because the chalk will become wet due to the condensation inside wells.

5.0 PROCEDURES

5.1 Preparation

The following steps must be taken when preparing to take a water level measurement:

- Assign a designated field logbook to record all field events and measurements according to CDM SOP 4-1. Document any and all deviations from SOPs and site-specific plans in the logbook and include rationale for the changes.
- Standing upwind from the well, open the groundwater well. Monitor the well with a photo ionization detector (PID), flame ionization detector (FID), or equivalent vapor analyzer as soon as the cap is opened, as dictated by the site-specific health and safety plan.

For comparability, water level measurements should always be referenced to the same vertical (elevation) datum marker, such as a U. S. Geological Survey (USGS) vertical and horizontal control point monument. Elevation datum obtained from the measurement of static water levels should be referenced to Mean Sea Level unless otherwise specified in the site-specific plans.

The measurement point must be as permanent as possible, clearly defined, marked, and easily located. Frequently, the top of the PVC riser is designated as the measurement point. However, since the top of

WATER LEVEL MEASUREMENT

SOP: 1-6

Revision: 4

Date: December 11, 2002

Page: 5 of 9

the riser is seldom smooth and horizontal, one particular point on the riser pipe should be designated and clearly marked. This can be accomplished by marking a point on the top of the riser pipe with a permanent marker. To avoid spilling liquids into the well, paints or other liquid marking materials should not be used. The protective outer casing can also be used as the measurement point if required. However, due to frost heave or other outside influences, which may change the casing elevation, this is less desirable than the well riser pipe.

5.2 Water Level Measurement Using Electronic Water Level Indicators

The following steps must be followed when taking water level measurements using electrical tapes:

1. Before lowering the probe into the well, the circuitry should be checked by dipping the probe in tap water and checking to ensure that the signaling device responds to probe submergence. The probe should then be lowered slowly into the well until contact with the water surface is indicated. The electrical tape reading is made at the measuring point. Take a second check reading before completely withdrawing the tape from the well to verify the measurement.
2. Independent electrical tape measurements of static water levels using the tape should agree within ± 0.01 foot for depths of less than about 200 feet. At greater depths, independent measurements may not be this close. For a depth of about 500 feet, the maximum difference of independent measurement using the same tape should be within ± 0.1 foot.
3. Decontaminate the electrical tape according to CDM SOP 4-5 before proceeding to the next well to minimize cross contamination.

It may be necessary to check the electrical tape length with a graduated steel tape after the line has been used for a long period of time (at least annually) or after it has been pulled hard in attempting to free the line. Some electrical tapes, especially the single line wire, are subject to permanent stretch. Because the probe is larger in diameter than the wire, the probe can become lodged in a well that may contain pumps or other groundwater measuring equipment.

5.3 Water Level Measurement Using Graduated Steel Tape

The following steps must be followed when taking water level measurement using a graduated steel tape:

1. Chalk the lower few feet of the tape by pulling the tape across a piece of blue carpenter's chalk.
2. Lower the graduated steel tape and weight from the measuring point at the top of the well into the water slowly to prevent splashing until a short length (less than chalked distance) of the tape

WATER LEVEL MEASUREMENT

SOP: 1-6

Revision: 4

Date: December 11, 2002

Page: 6 of 9

is submerged. Read the tape at the measurement point. Submergence of the weight and tape may temporarily cause a water level rise in wells or piezometers having very small diameters. This effect can be significant if the well exists in materials of very low hydraulic conductivity. Under dry surface conditions it may be desirable to pull the tape from the well by hand, being careful not to allow the tape to become kinked, and to read the water mark before rewinding the tape onto the reel. In this way, the water mark on the chalked part of the tape is rapidly brought to the surface before the wetted part of the tape dries. In cold regions, rapid withdrawal of the tape from the well is necessary before the wet part freezes and becomes difficult to read. Read the water mark on the tape. The difference between the measurement point and the water mark readings is the depth to the water.

3. To ensure accurate readings, two measurements should be taken and recorded in the logbook. If two measurements of static water level do not agree within about 0.01 foot (generally regarded as the practical limit of precision), continue to measure until the reason for the lack of agreement is determined or until the results are shown to be reliable based upon three measurements within 0.01 foot. Where water is dripping into the hole or is covering the well, it may be impossible to get a good watermark on the chalked tape.
4. Decontaminate, according to CDM SOP 4-5, the portion of steel tape that was placed into the well before proceeding to another well to minimize cross contamination.

5.4 Other Water Level Measurement Methods

Although the two methods cited above (especially the electronic water level indicator) predominate in the environmental sector, there are a number of other methods available which may be well suited for a particular purpose. Please note: caution must always be exercised to prevent inappropriate or contaminated materials from entering an environmental well.

5.4.1 Ultrasonic Method

The ultrasonic method electronically measures the amount of time it takes a sound wave to reach and reflect off the water surface and return to the ground surface. These instruments contain electronic microprocessors, capable of performing this measurement many times each second. The actual depth to water, as calculated by the microprocessor, is an average of many individual and separate readings.

5.4.2 Pressure Gauge Method

This method, also called the Air-Line Submergence Method, uses a pressure gauge and is the preferred method for pumping wells. An air line constructed of semi-rigid tubing is inserted into the well below the water table. The tube end is connected to an air tank or compressor and pressure gauge. Filtered air

WATER LEVEL MEASUREMENT

SOP: 1-6

Revision: 4

Date: December 11, 2002

Page: 7 of 9

is then forced through the tube and the resultant pressure is read in pounds per square inch (psi). This reading is converted to feet of water in the column and subtracted from the total tube length to give depth to water. Readings are then converted to groundwater elevation. Results are plotted on a field logging form. Calibration records and the exact procedures used must be maintained.

5.4.3 Popper Method

A popper is a metal cylinder, 2 to 3 inches in length and approximately 1 inch in diameter with a concave bottom. The popper is attached to a measuring tape and lowered into the well to within several inches of the water level. The popper is then dropped until a "popping" sound is heard, noting the tape reading at this point. This action is repeated several times and depth to water is determined in this manner.

5.4.4 Acoustic Probe Method

The acoustic probe is an electronic device containing two electrodes and a battery-powered transducer. The probe is attached to a tape. The probe is dropped into the well until a sound is detected, indicating the electrodes in the probe have contacted the water surface. This method is similar to the electrical probe method discussed in Section 5.2.

5.4.5 Continuous Recording Method

The measurement of groundwater elevations within pumping or monitoring wells can be accomplished by the use of a mechanical or digital-analog computerized continuous recording system and should be performed according to specifications given by the manufacturer of each unit. In general, when using either the mechanical or digital system, the pressure or electrical transducer is lowered into the well until it intersects the water surface. The actual depth to water is then measured by one of the methods described above and used to calibrate the continuous recorder.

The necessary adjustments and preparations are then completed according to the specifications given for each type of continuous recorder. Proper maintenance of continuous recording devices during water level monitoring should be performed such that continuous, permanent records are developed for the specified period of time. Records shall be stored on mechanical graph paper or on a microprocessor. Frequent calibrations of equipment shall also be made during monitoring periods of long duration in accordance with the manufacturers specifications.

WATER LEVEL MEASUREMENT

SOP: 1-6

Revision: 4

Date: December 11, 2002

Page: 8 of 9

6.0 RESTRICTIONS/LIMITATIONS

6.1 Groundwater and Miscible Fluids

Where water is rapidly dripping or flowing into a well, either from the top of the well or from fractures, obtaining an accurate reading may not be possible.

The effect of the water flowing into the well may interfere with an electronic water level measuring device resulting in a false water level measurement. Also, the "splashing" of the water surface makes obtaining consistent results by the wetted-tape method impossible. If water levels must be recorded in wells completed in aquifers that are recharging or discharging, the electronic water level indicator is the preferred measuring device, but should be used with the awareness of possible false measurements. To minimize the effects of "splashing", a 1-inch pipe (decontaminated for environmental wells) may be lowered into the pumping well to minimize the effect of disturbance and protect the probe from potential damage due to down-hole equipment (i.e., submersible pumps).

6.2 Immiscible Fluids

For wells containing immiscible contaminants, the field personnel will need to use special procedures for the measurement of fluid levels. The procedure to follow will depend on whether layers are light immiscibles that form lenses floating on the top of the water table, or dense immiscibles that sink through the aquifer and form lenses over less permeable layers.

In the case of light immiscibles, measurements of immiscible fluid and water levels cannot be accomplished by using normal techniques. For example, a chalked steel tape measurement will only indicate the depth to the immiscible fluid (not the depth to water), and a conventional electrical tape often will not respond to nonconducting immiscible fluids.

Techniques have been specially developed to measure fluid levels in wells containing immiscible fluids, particularly petroleum products. One method is similar to the chalked steel tape method. The difference is the use of a special paste or gel rather than ordinary carpenter's chalk, which, when applied to the end of the steel tape and submerged in the well, will show the top of the oil as a wet line and the top of the water as a distinct color change. Another method is similar to the electrical tape method.

The difference is that an interface probe is used that can detect the presence of conducting and nonconducting fluids. Thus, if a well is contaminated with low density, nonconducting immiscible fluids such as gasoline, the probe will first detect the surface of the gasoline, but it will not register electrical conduction; however, when the probe is lowered deeper to contact water, it will detect electrical conduction. Normally, a variation in an audible signal indicates the difference between phases.

WATER LEVEL MEASUREMENT

SOP: 1-6

Revision: 4

Date: December 11, 2002

Page: 9 of 9

Both of these methods have disadvantages. These methods are less effective with heavier and less refined petroleum products because the product tends to stick to the tape or probe, giving a greater product thickness measurement than it should. Paste or gel cannot be used when sampling groundwater for the same constituents present in the paste or gel product.

Note that water levels obtained in this situation are not suitable without further interpretation for determining hydraulic gradients. To use those data for determining hydraulic gradients, the differences in density between the light immiscible and water have to be accounted for.

Measuring fluid levels in wells screened in lenses of dense immiscible fluids resting on a low permeability formation is somewhat easier, provided the immiscible fluid is nonconducting. The top of the dense layer can be identified by simply using an electrical sounder. As an electrical sounder passes from groundwater into the immiscible phase, the detection unit will deactivate because the fluid will no longer conduct electricity. A better method would be to use an interface probe as described above. The variation in the audible signal associated with the detection of differing phase liquids will also allow the user to obtain a groundwater depth and dense immiscible thickness measurement.

7.0 REFERENCES

Camp Dresser & McKee Inc., et al. *Sampling and Analysis Procedures Geophysical Survey Procedures*, May 1991.

U.S. Environmental Protection Agency, *A Compendium of Superfund Field Operations Methods*. EPA/540/P-87/001, December 1987.

Westinghouse Savannah River Company, *Standard Operating Procedures Manual*, 3Q5, Chapter 13, Revision 1, Hydrogeologic Data Collection Procedures and Specifications, October 1992.

PACKAGING AND SHIPPING OF ENVIRONMENTAL SAMPLES

SOP: 2-1

Revision: 1

Date: June 20, 2001

Page 1 of 27

Prepared: Krista Lippoldt

Technical Review: Brian Jenks

QA Review: David O. Johnson

Approved: [Signature]

Signature/Date

Issued: [Signature]

Signature/Date

1.0 PACKAGING AND SHIPPING OF ALL SAMPLES – This standard operating procedure (SOP) applies to the packaging and shipping of all environmental samples. If the sample is preserved or radioactive, the following sections may also be applicable.

Section 2.0 – Packaging and Shipping of Samples Preserved with Hexane

Section 3.0 – Packaging and Shipping of Samples Preserved with Sodium Hydroxide

Section 4.0 – Packaging and Shipping of Samples Preserved with Hydrochloric Acid

Section 5.0 – Packaging and Shipping of Samples Preserved with Nitric Acid

Section 6.0 – Packaging and Shipping of Samples Preserved with Sulfuric Acid

Section 7.0 – Packaging and Shipping of Limited Quantity Radioactive Samples

1.1 OBJECTIVE

The objective of this SOP is to outline the requirements for the packaging and shipment of environmental samples.

1.2 BACKGROUND

1.2.1 Definitions

Environmental Sample - An environmental sample is any sample that has less than reportable quantities for any hazardous constituents according to Department of Transportation (DOT) regulations promulgated in 49 CFR - Part 172.

Custody Seal – A custody seal is a narrow adhesive-backed seal that is applied to individual sample containers and/or the sample shipping container (i.e. cooler) before offsite shipment. Custody seals are used as a protective mechanism to ensure that sample integrity is not compromised during transportation from the field to the analytical laboratory.

Secondary Containment – A secondary containment is the container that the sample is shipped in (i.e., plastic overpackaging if liquid sample is collected in glass).

Exempted Quantity – Exempted quantity is the amount of hazardous material that does not fall under DOT/IATA/ICAO regulations. This exemption is very difficult to meet; most shipments will be made under limited quantity.

PACKAGING AND SHIPPING OF ENVIRONMENTAL SAMPLES

SOP: 2-1

Revision: 1

Date: June 20, 2001

Page 2 of 27

Limited Quantity – Limited quantity is the maximum amount of a hazardous material for which there is a specific labeling or packaging exception.

Performance Testing – Performance testing is the required testing of outer packaging. These tests include the drop and stacking test.

Qualified Shipper – A qualified shipper is a person who has been adequately trained to perform the functions of shipping hazardous materials.

1.2.2 Discussion

Proper packaging and shipping is necessary to ensure the protection of the integrity of environmental samples shipped for analysis.

1.2.3 Associated Procedure

- CDM Federal SOP 1-2, Sample Custody

1.3 RESPONSIBILITIES

Field Team Leader (FTL) - The field team leader is responsible for ensuring that packaging and sampling procedures are conducted in accordance with this SOP. The field team leader is also responsible for ensuring that CDM Federal properly coordinates laboratory analysis of samples.

1.4 REQUIRED EQUIPMENT

- Coolers with return address of CDM Federal office
- Heavy-duty plastic garbage bags
- Plastic Ziploc®-type bags, small and large
- Clear tape
- Fiber tape – nylon reinforced strapping tape
- Duct tape
- Vermiculite (or equivalent)*
- Bubble wrap (optional)
- Ice
- Custody seals
- Completed chain-of-custody record or CLP custody records, if applicable
- Completed bill of lading
- "This End Up" and directional arrow labels

* Check for any client-specific or laboratory requirements related to the use of absorbent packaging materials.

PACKAGING AND SHIPPING OF ENVIRONMENTAL SAMPLES

SOP: 2-1

Revision: 1

Date: June 20, 2001

Page 3 of 27

1.5 PROCEDURES

The following steps must be followed when packing sample bottles and jars for shipment:

1. Verify the samples undergoing shipment meet the definition of "Environmental Sample" and are not a hazardous material as defined by DOT. Professional judgment and/or consultation with the appropriate health and safety coordinator or the health and safety manager should be observed.
2. Select a sturdy cooler in good repair. Secure and tape the drain plug with fiber or duct tape. Line the cooler with a large heavy-duty plastic garbage bag.
3. Be sure the caps on all bottles are tight (will not leak); check to see that labels and chain-of-custody records are completed properly (SOP 1-2, Sample Custody).
4. Place all bottles in separate and appropriately sized plastic zip-top bags and close the bags. Up to three VOA vials may be packed in one bag. Bottles may be wrapped in bubble wrap. Optionally, place three to six VOA vials in a quart metal can and then fill the can with vermiculite or equivalent. Note: Trip blanks must be included in coolers containing VOA samples.
5. Place 2 to 4 inches of vermiculite (or equivalent) into a cooler that has been lined with a garbage bag, and then place the bottles and cans in the bag with sufficient space to allow for the addition of more packing material between the bottles and cans. It is preferable to place glass sample bottles and jars into the cooler vertically. Due to the strength properties of a glass container, there is much less chance for breakage when the container is packed vertically rather than horizontally.
6. Put ice in large plastic zip-top bags (double bagging the zip-tops is preferred) and properly seal. Place the ice bags on top of and/or between the samples. Several bags of ice are required (dependant on outdoor temperature, staging time, etc.) to maintain the cooler temperature at approximately 4° centigrade. Fill all remaining space between the bottles or cans with packing material. Securely fasten the top of the large garbage bag with fiber or duct tape.
7. Place the completed chain-of-custody record or the CLP traffic report form (if applicable) for the laboratory into a plastic zip-top bag, seal the bag, tape the bag to the inner side of the cooler lid and close the cooler.
8. The cooler lid shall be secured with nylon reinforced strapping tape by wrapping each end of the cooler a minimum of two times. Attach a completed chain-of-custody seal across the hinges of the cooler on opposite sides. The custody seals should be affixed to the cooler with half of the seal on the strapping tape so that the cooler cannot be opened without breaking the seal. Complete two more wraps around with fiber tape and place clear tape over the custody seals.

PACKAGING AND SHIPPING OF ENVIRONMENTAL SAMPLES

SOP: 2-1

Revision: 1

Date: June 20, 2001

Page 4 of 27

9. The shipping container lid must be marked "THIS END UP" and arrow labels that indicate the proper upward position of the container should be affixed to the cooler. A label containing the name and address of the shipper (CDM Federal) shall be placed on the outside of the container. Labels used in the shipment of hazardous materials (such as Cargo Only Air Craft, Flammable Solids, etc.) are not permitted on the outside of containers used to transport environmental samples and shall not be used. The name and address of the laboratory shall be placed on the container, or when shipping by common courier, the bill of lading shall be completed and attached to the lid of the shipping container.

1.6 RESTRICTIONS/LIMITATIONS

The holding times for the samples packed for shipment must not be exceeded. It is recommended that samples be packed in time to be shipped nightly for overnight delivery. Use caution when shipping samples for weekend delivery; make arrangements with the laboratory before sending samples.

2.0 PACKAGING AND SHIPPING OF SAMPLES PRESERVED WITH HEXANE

2.1 OBJECTIVE

This section provides guidance for the shipment of soil and water environmental samples regulated under the DOT Hazardous Materials Regulations and the IATA/ICAO Dangerous Goods Regulations for shipment by air and applies only to domestic shipments.

2.2 BACKGROUND

2.2.1 Definitions

Section 1.2.1 defines the terms relevant to this section.

2.2.2 Transportation

This section was prepared for the shipment of hexane-preserved samples.

2.2.3 Containers

- 40 ml glass VOA vials (up to 1L per outer package)

PACKAGING AND SHIPPING OF ENVIRONMENTAL SAMPLES

SOP: 2-1

Revision: 1

Date: June 20, 2001

Page 5 of 27

2.3 RESPONSIBILITY

It is the responsibility of the qualified shipper to ensure that each shipment contains no more than the maximum of 24 VOA vials for a total liquid volume of 1 liter and that the shipment is packaged according to IATA/ICAO packaging instruction Y305 for limited quantities of hexane.

REQUIRED EQUIPMENT

- Outer packaging (for limited quantities) insulated cooler that has passed the performance test
- Garbage bags
- Clear tape
- Duct tape
- Strapping tape (optional)
- Ziploc®-type bags, small and large
- Vermiculite (or equivalent)*
- Bubble wrap
- Ice
- Chain-of-custody seals
- Chain-of-custody form
- Survey documentation (if shipping from Department of Energy [DOE] or radiological sites)
- Class 3 flammable liquid labels
- Orientation labels
- Consignor/consignee labels

* Check for any client-specific or laboratory requirements related to the use of absorbent packaging materials.

2.5 PACKAGING

The following steps are to be followed when packaging limited quantity samples shipments.

- Tape any interior opening in the cooler (drain plug) from the inside to ensure control of interior contents. Also, tape the drain plug from the outside of the cooler.
- All sample containers will be properly labeled and the label protected with waterproof tape prior to sampling.
- At a minimum the label must contain:
 - Project name
 - Project number
 - Date and time of sample collection
 - Sample location
 - Sample identification number
 - Collector's initials

PACKAGING AND SHIPPING OF ENVIRONMENTAL SAMPLES

SOP: 2-1

Revision: 1

Date: June 20, 2001

Page 6 of 27

- Preservative (note amount of preservative used in miscellaneous section of the chain-of-custody)
- Wrap each container (40 ml VOA vials) in bubble wrap (secure with waterproof tape) to prevent breakage.
- Place the bubble wrapped container into a 2.7 mil Ziploc®-type bag, removing trapped air.
- Place wrapped containers inside a polyethylene bottle filled with vermiculite; seal the bottle. (Maximum of 4 VOA vials will fit inside a 500-ml wide-mouth polyethylene bottle.)
- Place sufficient amount of vermiculite in the bottom of the cooler to absorb any leakage that may occur.
- Place a garbage bag in the cooler.
- Pack the samples appropriately inside the garbage bag (bottles placed upright) to prevent movement during shipment.
- Place a sufficient amount of double-bagged ice around the samples to maintain the required temperature during shipment.
- Seal the garbage bag by tying or taping.
- The maximum weight of the cooler shall not exceed 30 kg (66 lbs) for any limited quantity shipment of dangerous goods.
- Secure the chain-of-custody form (placed inside a Ziploc®-type bag) to the interior of the cooler lid.
- If the shipment is from a DOE or other facility, place the results of the radiation screen and cooler/sample survey with the chain-of-custody.
- Wrap strapping tape or duct tape around both ends of the cooler and around the cooler lid.
- Affix custody seals to opposite sides of the cooler lid. Cover the custody seals with clear waterproof tape.
- Mark the outside of the cooler with the proper shipping name of the contents, corresponding UN number, and LTD. QTY. (as shown below).

HEXANES MIXTURE UN1208 LTD. QTY.

- Place a label on the front of the cooler with the company name, contact name, phone number, full street address, and state with zip code for both shipper and recipient.
- Affix a Flammable Liquid label to the outside of the cooler.
- Affix package orientation labels on two opposite sides of the cooler.
- Secure the marking and labels to the surface of the cooler with clear waterproof tape to prevent accidental removal during shipment.
- An example of cooler labeling/marketing locations is shown in Figure 1.

NOTE: No marking or labeling can be obscured by strapping or duct tape.

PACKAGING AND SHIPPING OF ENVIRONMENTAL SAMPLES

SOP: 2-1

Revision: 1

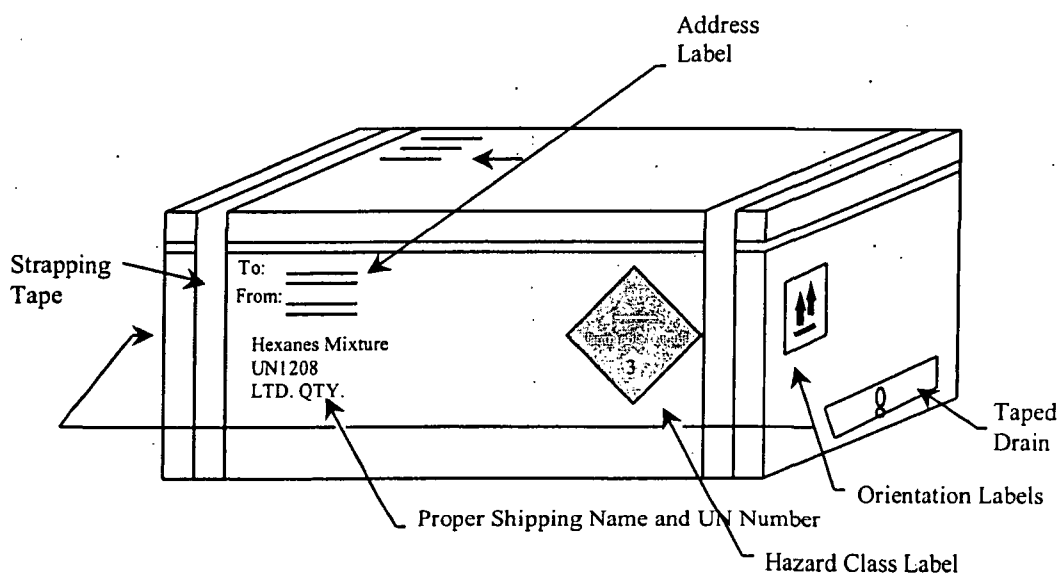
Date: June 20, 2001

Page 7 of 27

NOTE: The inner packaging of dangerous goods may be placed into the designated cooler for shipment. Other non-regulated environmental samples may be added to the cooler for shipment.

- When shipping from a DOE facility, the cooler will be surveyed by a qualified radiation control technician to ensure the exterior surfaces do not exceed 0.5 mrem/h on all sides. This survey will be documented and the results reviewed by the qualified shipper.
- Complete the Dangerous Goods and Hazardous Materials Inspection Checklist for Shipping Limited Quantity (Appendix A).
- Complete a Dangerous Goods Airbill.

Figure 1 Example of Cooler Label/Marking Locations



3.0 PACKAGING AND SHIPPING OF SAMPLES PRESERVED WITH SODIUM HYDROXIDE

3.1 OBJECTIVE

This section provides guidance for the shipment of soil and water environmental samples regulated under the DOT Hazardous Materials Regulations and the IATA/ICAO Dangerous Goods Regulations for shipment by air and applies only to domestic shipments.

PACKAGING AND SHIPPING OF ENVIRONMENTAL SAMPLES

SOP: 2-1

Revision: 1

Date: June 20, 2001

Page 8 of 27

3.2 BACKGROUND

3.2.1 Definitions

Section 1.2.1 defines the terms relevant to this section.

3.2.2 Transportation

This section was prepared for the shipment of sodium hydroxide (NaOH) preserved samples.

3.2.3 Containers

The inner packaging container (and amount of preservative) that may be used for these shipments includes:

Exempted Quantities of Preservatives

Preservative		Desired in Final Sample		Quantity of Preservative (ml) for Specified Container				
				40 ml	125 ml	250 ml	500 ml	1 L
NaOH	30%	pH >12	Conc. 0.08%		.25	0.5	1	2

5 drops = 1 ml

3.3 RESPONSIBILITY

It is the responsibility of the qualified shipper to determine the amount of preservative in each sample so that accurate determination of quantities can be made.

REQUIRED EQUIPMENT

- Outer packaging (for limited quantities) insulated cooler that has passed the performance test.
- Garbage bags
- Clear tape
- Duct tape
- Strapping tape (optional)
- Ziploc®-type bags, small and large
- Vermiculite (or equivalent)*
- Bubble wrap (optional)
- Ice
- Custody seals
- Chain-of-custody form

PACKAGING AND SHIPPING OF ENVIRONMENTAL SAMPLES

SOP: 2-1

Revision: 1

Date: June 20, 2001

Page 9 of 27

- Survey documentation (if shipping from Department of Energy [DOE] or radiological sites)
 - Class 8 corrosive labels
 - Orientation labels
 - Consignor/consignee labels
- * Check for any client-specific or laboratory requirements related to the use of absorbent packaging materials.

3.5 PACKAGING

Samples containing NaOH as a preservative that exceed the exempted concentration of 0.08 percent (2 ml of a 30 percent per liter) will be shipped as a limited quantity per packing instruction Y809 of the IATA/ICAO Dangerous Goods Regulations.

The following steps are to be followed when packaging limited quantity samples shipments.

- Tape any interior opening in the cooler (drain plug) from the inside to ensure control of interior contents. Also, tape the drain plug from the outside of the cooler.
- All sample containers will be properly labeled and the label protected with waterproof tape prior to sampling.
- At a minimum the label must contain:
 - Project name
 - Project number
 - Date and time of sample collection
 - Sample location
 - Sample identification number
 - Collector's initials
 - Preservative (note amount of preservative used in miscellaneous section of the chain-of-custody)
- This step is optional; wrap each container in bubble wrap (secure with waterproof tape) to prevent breakage.
- Place the bubble wrapped container into a 2.7 mil Ziploc®-type bag, removing trapped air.
- Place glass containers inside a polyethylene bottle filled with vermiculite; seal the bottle.
- Place sufficient amount of vermiculite in the bottom of the cooler to absorb any leakage that may occur.
- Place a garbage bag in the cooler.
- Pack the samples appropriately inside the garbage bag (bottles placed upright) to prevent movement during shipment.
- Place a sufficient amount of double-bagged ice around the samples to maintain the required temperature during shipment.
- Seal the garbage bag by tying or taping.
- The maximum weight of the cooler shall not exceed 30 kg (66 lbs) for any limited quantity shipment of dangerous goods.

PACKAGING AND SHIPPING OF ENVIRONMENTAL SAMPLES

SOP: 2-1

Revision: 1

Date: June 20, 2001

Page 10 of 27

- Secure the chain-of-custody form (placed inside a Ziploc®-type bag) to the interior of the cooler lid.
- If the shipment is from a DOE or other facility, place the results of the radiation screen and cooler/sample survey with the chain-of-custody.
- Wrap strapping tape or duct tape around both ends of the cooler and around the cooler lid.
- Affix custody seals to opposite sides of the cooler lid. Cover the custody seals with clear waterproof tape.
- Mark the outside of the cooler with the proper shipping name of the contents, corresponding UN number, and LTD. QTY. (as shown below).

SODIUM HYDROXIDE SOLUTION
UN1824
LTD. QTY.

- Place a label on the front of the cooler with the company name, contact name, phone number, full street address, and state with zip code for both shipper and recipient.
- Affix a Corrosive label to the outside of the cooler.
- Affix package orientation labels on two opposite sides of the cooler.
- Secure the marking and labels to the surface of the cooler with clear waterproof tape to prevent accidental removal during shipment.
- An example of cooler labeling/marketing locations is shown in Figure 1.

NOTE: Samples meeting the exemption concentration of 0.08 percent NaOH by weight will be shipped as non-regulated or non-hazardous.

NOTE: No marking or labeling can be obscured by strapping or duct tape.

NOTE: The inner packaging of dangerous goods may be placed into the designated cooler for shipment. Other non-regulated environmental samples may be added to the cooler for shipment.

- When shipping from a DOE facility, the cooler will be surveyed by a qualified radiation control technician to ensure the exterior surfaces do not exceed 0.5 mrem/h on all sides. This survey will be documented and the results reviewed by the qualified shipper.
- Complete the Dangerous Goods and Hazardous Materials Inspection Checklist for Shipping Limited Quantity (Appendix A).
- Complete a Dangerous Goods Airbill.

PACKAGING AND SHIPPING OF ENVIRONMENTAL SAMPLES

SOP: 2-1

Revision: 1

Date: June 20, 2001

Page 11 of 27

4.0 PACKAGING AND SHIPPING OF SAMPLES PRESERVED WITH HYDROCHLORIC ACID

4.1 OBJECTIVE

This section provides guidance for the shipment of soil and water environmental samples regulated under the DOT Hazardous Materials Regulations and the IATA/ICAO Dangerous Goods Regulations for shipment by air and applies only to domestic shipments.

4.2 BACKGROUND

4.2.1 Definitions

Section 1.2.1 defines the terms relevant to this section.

4.2.2 Transportation

This section was prepared for the shipment of hydrochloric acid (HCl) preserved samples.

4.2.3 Containers

The inner packaging container (and amount of preservative) that may be used for these shipments includes:

Exempted quantities of preservatives

Preservative		Desired in Final Sample		Quantity of Preservative (ml) for Specified Container				
				40 ml	125 ml	250 ml	500 ml	1 L
pH	Conc.							
HCl	2N	<2	0.04%	.2	.5	1		

5 drops = 1 ml

4.3 RESPONSIBILITY

It is the responsibility of the qualified shipper to determine the amount of preservative in each sample so that accurate determination of quantities can be made.

4.4 REQUIRED EQUIPMENT

- Outer packaging (for limited quantities) insulated cooler that has passed the performance test.
- Garbage bags
- Clear tape

PACKAGING AND SHIPPING OF ENVIRONMENTAL SAMPLES

SOP: 2-1

Revision: 1

Date: June 20, 2001

Page 12 of 27

- Duct tape
- Strapping tape (optional)
- Ziploc®-type bags, small and large
- Vermiculite (or equivalent)*
- Bubble wrap
- Ice
- Custody seals
- Chain-of-custody form
- Survey documentation (if shipping from Department of Energy [DOE] or radiological sites)
- Class 8 corrosive labels
- Orientation labels
- Consignor/consignee labels

* Check for any client-specific or laboratory requirements related to the use of absorbent packaging materials.

4.5 PACKAGING

The following steps are to be followed when packaging limited quantity samples shipments.

- Tape any interior opening in the cooler (drain plug) from the inside to ensure control of interior contents. Also, tape the drain plug from the outside of the cooler.
- All sample containers will be properly labeled and the label protected with waterproof tape prior to sampling.
- At a minimum the label must contain:
 - Project name
 - Project number
 - Date and time of sample collection
 - Sample location
 - Sample identification number
 - Collector's initials
 - Preservative (note amount of preservative used in miscellaneous section of the chain-of-custody)
- Wrap each container (40 ml VOA vials) in bubble wrap (secure with waterproof tape) to prevent breakage.
- Place the bubble wrapped container into a 2.7 mil Ziploc®-type bag, removing trapped air.
- Place wrapped containers inside a polyethylene bottle filled with vermiculite; seal the bottle. (Maximum of 4 VOA vials will fit inside a 500-ml wide-mouth polyethylene bottle.)
- Place sufficient amount of vermiculite in the bottom of the cooler to absorb any leakage that may occur.
- Place a garbage bag in the cooler.

PACKAGING AND SHIPPING OF ENVIRONMENTAL SAMPLES

SOP: 2-1

Revision: 1

Date: June 20, 2001

Page 13 of 27

- Pack the samples appropriately inside the garbage bag (bottles placed upright) to prevent movement during shipment.
- Place a sufficient amount of double-bagged ice around the samples to maintain the required temperature during shipment.
- Seal the garbage bag by tying or taping.
- The maximum weight of the cooler shall not exceed 30 kg (66 lbs) for any limited quantity shipment of dangerous goods.
- Secure the chain-of-custody form (placed inside a Ziploc®-type bag) to the interior of the cooler lid.
- If the shipment is from a DOE or other facility, place the results of the radiation screen and cooler/sample survey with the chain-of-custody.
- Wrap strapping tape or duct tape around both ends of the cooler and around the cooler lid.
- Affix custody seals to opposite sides of the cooler lid. Cover the custody seals with clear waterproof tape.
- Mark the outside of the cooler with the proper shipping name of the contents, corresponding UN number, and LTD. QTY. (as shown below).

HYDROCHLORIC ACID SOLUTION

UN1789

LTD. QTY.

- Place a label on the front of the cooler with the company name, contact name, phone number, full street address, and state with zip code for both shipper and recipient.
- Affix a Corrosive label to the outside of the cooler.
- Affix package orientation labels on two opposite sides of the cooler.
- Secure the marking and labels to the surface of the cooler with clear waterproof tape to prevent accidental removal during shipment.
- An example of cooler labeling/marketing locations is shown in Figure 1.

NOTE: Samples meeting the exemption concentration of 0.04 percent HCl by weight will be shipped as non-regulated or non-hazardous.

NOTE: No marking or labeling can be obscured by strapping or duct tape.

NOTE: The inner packaging of dangerous goods may be placed into the designated cooler for shipment. Other non-regulated environmental samples may be added to the cooler for shipment.

- When shipping from a DOE facility, the cooler will be surveyed by a qualified radiation control technician to ensure the exterior surfaces do not exceed 0.5 mrem/h on all sides. This survey will be documented and the results reviewed by the qualified shipper.

PACKAGING AND SHIPPING OF ENVIRONMENTAL SAMPLES

SOP: 2-1

Revision: 1

Date: June 20, 2001

Page 14 of 27

- Complete the Dangerous Goods and Hazardous Materials Inspection Checklist for Shipping Limited Quantity (Appendix A).
- Complete a Dangerous Goods Airbill.

5.0 PACKAGING AND SHIPPING OF SAMPLES PRESERVED WITH NITRIC ACID

5.1 OBJECTIVE

This section provides guidance for the shipment of soil and water environmental samples regulated under the DOT Hazardous Materials Regulations and the IATA/ICAO Dangerous Goods Regulations for shipment by air and applies only to domestic shipments.

5.2 BACKGROUND

5.2.1 Definitions

Section 1.2.1 defines the terms relevant to this section.

5.2.2 Transportation

This section was prepared for the shipment of nitric acid (HNO₃) preserved samples.

5.2.3 Containers

The inner packaging container (and amount of preservative) that may be used for these shipments includes:

Exempted quantities of preservatives

Preservative		Desired in Final Sample		Quantity of Preservative (ml) for Specified Container				
				40 ml	125 ml	250 ml	500 ml	1 L
HNO ₃	6N	pH <2	Conc. 0.15%		2	4	5	8

5 drops = 1 ml

5.3 RESPONSIBILITY

It is the responsibility of the qualified shipper to determine the amount of preservative in each sample so that accurate determination of quantities can be made.

PACKAGING AND SHIPPING OF ENVIRONMENTAL SAMPLES

SOP: 2-1

Revision: 1

Date: June 20, 2001

Page 15 of 27

5.4 REQUIRED EQUIPMENT

- Outer packaging (for limited quantities) insulated cooler that has passed the performance test.
- Garbage bags
- Clear tape
- Duct tape
- Strapping tape (optional)
- Ziploc®-type bags, small and large
- Vermiculite (or equivalent)*
- Bubble wrap (optional)
- Ice
- Custody seals
- Chain-of-custody form
- Survey documentation (if shipping from Department of Energy [DOE] or radiological sites)
- Class 8 corrosive labels
- Orientation labels
- Consignor/consignee labels

* Check for any client-specific or laboratory requirements related to the use of absorbent packaging materials.

5.5 PACKAGING

Samples containing HNO_3 as a preservative that exceed the exempted concentration of 0.15% HNO_3 will be shipped as a limited quantity per packing instruction Y807 of the IATA/ICAO Dangerous Goods Regulations.

The following steps are to be followed when packaging limited quantity samples shipments.

- Tape any interior opening in the cooler (drain plug) from the inside to ensure control of interior contents. Also, tape the drain plug from the outside of the cooler.
- All sample containers will be properly labeled and the label protected with waterproof tape prior to sampling.
- At a minimum the label must contain:
 - Project name
 - Project number
 - Date and time of sample collection
 - Sample location
 - Sample identification number
 - Collector's initials
 - Preservative (note amount of preservative used in miscellaneous section of the chain-of-custody)

PACKAGING AND SHIPPING OF ENVIRONMENTAL SAMPLES

SOP: 2-1

Revision: 1

Date: June 20, 2001

Page 16 of 27

- This step is optional; wrap each container in bubble wrap (secure with waterproof tape) to prevent breakage.
- Place the bubble wrapped container into a 2.7 mil Ziploc®-type bag, removing trapped air.
- Place glass containers inside a polyethylene bottle filled with vermiculite; seal the bottle.
- Place sufficient amount of vermiculite in the bottom of the cooler to absorb any leakage that may occur.
- Place a garbage bag in the cooler.
- Pack the samples appropriately inside the garbage bag (bottles placed upright) to prevent movement during shipment.
- Place a sufficient amount of double-bagged ice around the samples to maintain the required temperature during shipment.
- Seal the garbage bag by tying or taping.
- The maximum weight of the cooler shall not exceed 30 kg (66 lbs) for any limited quantity shipment of dangerous goods.
- Secure the chain-of-custody form (placed inside a Ziploc®-type bag) to the interior of the cooler lid.
- If the shipment is from a DOE or other facility, place the results of the radiation screen and cooler/sample survey with the chain-of-custody.
- Wrap strapping tape or duct tape around both ends of the cooler and around the cooler lid.
- Affix custody seals to opposite sides of the cooler lid. Cover the custody seals with clear waterproof tape.
- Mark the outside of the cooler with the proper shipping name of the contents, corresponding UN number, and LTD. QTY. (as shown below).

NITRIC ACID SOLUTION (with less than 20%)
UN2031
LTD. QTY.

- Place a label on the front of the cooler with the company name, contact name, phone number, full street address, and state with zip code for both shipper and recipient.
- Affix a Corrosive label to the outside of the cooler.
- Affix package orientation labels on two opposite sides of the cooler.
- Secure the marking and labels to the surface of the cooler with clear waterproof tape to prevent accidental removal during shipment.
- An example of cooler labeling/marketing locations is shown in Figure 1.

NOTE: Samples meeting the exemption concentration of 0.15 percent HNO_3 by weight will be shipped as non-regulated or non-hazardous.

NOTE: No marking or labeling can be obscured by strapping or duct tape.

PACKAGING AND SHIPPING OF ENVIRONMENTAL SAMPLES

SOP: 2-1

Revision: 1

Date: June 20, 2001

Page 17 of 27

NOTE: The inner packaging of dangerous goods may be placed into the designated cooler for shipment. Other non-regulated environmental samples may be added to the cooler for shipment.

- When shipping from a DOE facility, the cooler will be surveyed by a qualified radiation control technician to ensure the exterior surfaces do not exceed 0.5 mrem/h on all sides. This survey will be documented and the results reviewed by the qualified shipper.
- Complete the Dangerous Goods and Hazardous Materials Inspection Checklist for Shipping Limited Quantity (Appendix A).
- Complete a Dangerous Goods Airbill.

6.0 PACKAGING AND SHIPPING OF SAMPLES PRESERVED WITH SULFURIC ACID

6.1 OBJECTIVE

This section provides guidance for the shipment of soil and water environmental samples regulated under the DOT Hazardous Materials Regulations and the IATA/ICAO Dangerous Goods Regulations for shipment by air and applies only to domestic shipments.

6.2 BACKGROUND

6.2.1 Definitions

Section 1.2.1 defines the terms relevant to this section.

6.2.2 Transportation

This section was prepared for the shipment of sulfuric acid (H_2SO_4) preserved samples.

6.2.3 Containers

The inner packaging container (and amount of preservative) that may be used for these shipments includes:

Exempted quantities of preservatives

Preservative		Desired in Final Sample		Quantity of Preservative (ml) for Specified Container				
				40 ml	125 ml	250 ml	500 ml	1 L
H_2SO_4	37N	pH	Conc.					
		<2	0.35%	.1	.25	0.5	1	2

5 drops = 1 ml

PACKAGING AND SHIPPING OF ENVIRONMENTAL SAMPLES

SOP: 2-1

Revision: 1

Date: June 20, 2001

Page 18 of 27

6.3 RESPONSIBILITY

It is the responsibility of the qualified shipper to determine the amount of preservative in each sample so that accurate determination of quantities can be made.

6.4 REQUIRED EQUIPMENT

- Outer packaging (for limited quantities) insulated cooler that has passed the performance test.
- Garbage bags
- Clear tape
- Duct tape
- Strapping tape (optional)
- Ziploc®-type bags, small and large
- Vermiculite (or equivalent)*
- Bubble wrap
- Ice
- Custody seals
- Chain-of-custody form
- Survey documentation (if shipping from Department of Energy [DOE] or radiological sites)
- Class 8 corrosive labels
- Orientation labels
- Consignor/consignee labels

* Check for any client-specific or laboratory requirements related to the use of absorbent packaging materials.

6.5 PACKAGING

Samples containing H_2SO_4 as a preservative that exceed the exempted concentration of 0.35 percent will be shipped as a limited quantity per packing instruction Y809 of the IATA/ICAO Dangerous Goods Regulations.

The following steps are to be followed when packaging limited quantity samples shipments.

- Tape any interior opening in the cooler (drain plug) from the inside to ensure control of interior contents. Also, tape the drain plug from the outside of the cooler.
- All sample containers will be properly labeled and the label protected with waterproof tape prior to sampling.
- At a minimum the label must contain:
 - Project name
 - Project number
 - Date and time of sample collection

PACKAGING AND SHIPPING OF ENVIRONMENTAL SAMPLES

SOP: 2-1

Revision: 1

Date: June 20, 2001

Page 19 of 27

- Sample location
- Sample identification number
- Collector's initials
- Preservative (note amount of preservative used in miscellaneous section of the chain-of-custody)
- Wrap each glass container in bubble wrap (secure with waterproof tape) to prevent breakage.
- Place the bubble wrapped container into a 2.7 mil Ziploc®-type bag, removing trapped air.
- Place glass containers inside a polyethylene bottle filled with vermiculite; seal the bottle.
- Place sufficient amount of vermiculite in the bottom of the cooler to absorb any leakage that may occur.
- Place a garbage bag in the cooler.
- Pack the samples appropriately inside the garbage bag (bottles placed upright) to prevent movement during shipment.
- Place a sufficient amount of double-bagged ice around the samples to maintain the required temperature during shipment.
- Seal the garbage bag by tying or taping.
- The maximum weight of the cooler shall not exceed 30 kg (66 lbs) for any limited quantity shipment of dangerous goods.
- Secure the chain-of-custody form (placed inside a Ziploc®-type bag) to the interior of the cooler lid.
- If the shipment is from a DOE or other facility, place the results of the radiation screen and cooler/sample survey with the chain-of-custody.
- Wrap strapping tape or duct tape around both ends of the cooler and around the cooler lid.
- Affix custody seals to opposite sides of the cooler lid. Cover the custody seals with clear waterproof tape.
- Mark the outside of the cooler with the proper shipping name of the contents, corresponding UN number, and LTD. QTY. (as shown below).

SULFURIC ACID SOLUTION

UN2796

LTD. QTY.

- Place a label on the front of the cooler with the company name, contact name, phone number, full street address, and state with zip code for both shipper and recipient.
- Affix a Corrosive label to the outside of the cooler.
- Affix package orientation labels on two opposite sides of the cooler.
- Secure the marking and labels to the surface of the cooler with clear waterproof tape to prevent accidental removal during shipment.
- An example of cooler labeling/markings is shown in Figure 1.

PACKAGING AND SHIPPING OF ENVIRONMENTAL SAMPLES

SOP: 2-1

Revision: 1

Date: June 20, 2001

Page 20 of 27

NOTE: Samples meeting the exemption concentration of 0.35 percent H_2SO_4 by weight will be shipped as non-regulated or non-hazardous.

NOTE: No marking or labeling can be obscured by strapping or duct tape.

NOTE: The inner packaging of dangerous goods may be placed into the designated cooler for shipment. Other non-regulated environmental samples may be added to the cooler for shipment.

- When shipping from a DOE facility, the cooler will be surveyed by a qualified radiation control technician to ensure the exterior surfaces do not exceed 0.5 mrem/h on all sides. This survey will be documented and the results reviewed by the qualified shipper.
- Complete the Dangerous Goods and Hazardous Materials Inspection Checklist for Shipping Limited Quantity (Appendix A).
- Complete a Dangerous Goods Airbill.

7.0 PACKAGING AND SHIPPING OF LIMITED QUANTITY RADIOACTIVE SAMPLES

7.1 OBJECTIVE

This section provides guidance for the shipment of soil and water environmental samples regulated under the DOT Hazardous Materials Regulations and the IATA/ICAO Dangerous Goods Regulations for shipment by air and applies only to domestic shipments.

7.2 BACKGROUND

7.2.1 Definitions

Section 1.2.1 defines the terms relevant to this section.

7.2.2 Transportation

This section was prepared for the shipment of environmental samples containing radioactive materials in limited quantities.

7.2.3 Containers

The inner packaging containers that may be used for these shipments include:

- Any size sample container

PACKAGING AND SHIPPING OF ENVIRONMENTAL SAMPLES

SOP: 2-1

Revision: 1

Date: June 20, 2001

Page 21 of 27

7.3 DESCRIPTION/RESPONSIBILITIES

- The qualified shipper will ship all samples that meet the Class 7 definition of radioactive materials and meet the activity requirements specified in Table 7 of 49 CFR 173.425, as Radioactive Materials in Limited Quantity. The qualified shipper will verify that all packages and their contents meet the requirements of 49 CFR 173.421, "Limited Quantities of Radioactive Materials."
- The packaging used for shipping will meet the general requirements for packaging and packages specified in 49 CFR 173.24 and the general design requirements provided in 173.410. These standards state that a package must be capable of withstanding the effects of any acceleration, vibration, or vibration resonance that may arise under normal condition of transport without any deterioration in the effectiveness of the closing devices on the various receptacles or in the integrity of the package as a whole and without loosening or unintentionally releasing the nuts, bolts, or other securing devices even after repeated use.
- If the shipment is from a Department of Energy (DOE) facility, radiological screenings will be completed on all samples taken. The qualified shipper will review the results of each screening (alpha, beta, and gamma speciation). Samples will not be shipped offsite until the radiological screening has been performed.
- The total activity for each package will not exceed the relevant limits listed in Table 7 of 49 CFR 173.425. The A_2 value of the material will be calculated based on all radionuclides found during previous investigations (if any) in the area from which the samples are derived. The A_2 values to be used will be the most restrictive of all potential radionuclides as listed in 49 CFR 173.435.
- The radiation level at any point on the external surface of the package bearing the sample(s) will not exceed 0.005 mSv/hour (0.5 mrem/hour). These will be verified by dose and activity monitoring prior to shipment of the package.
- The removable radioactive surface contamination on the external surface of the package will not exceed the limits specified in 49 CFR 173.443(a). CDM Federal will use the DOE-established free release criteria for removable surface contamination of less than 20 dpm/100 cm² (alpha) and 1000 dpm/100 cm² (beta/gamma). It should be noted that these values are more conservative than the DOT requirements for removable surface contamination.
- The qualified shipper will verify that the outside of the inner packaging is marked "Radioactive".
- The qualified shipper will verify that the excepted packages prepared for shipment under the provisions of 49 CFR 173.421 have a notice enclosed, or shown on the outside of the package, that reads, "This package conforms to the conditions and limitations specified in 49 CFR 173.421 for radioactive material, excepted package-limited quantity of material, UN2910".

PACKAGING AND SHIPPING OF ENVIRONMENTAL SAMPLES

SOP: 2-1

Revision: 1

Date: June 20, 2001

Page 22 of 27

7.4 REQUIRED EQUIPMENT

- Cooler or other acceptable outer packaging
- Garbage bags
- Clear tape
- Duct tape
- Strapping tape (optional)
- Ziploc®-type bags, small and large
- Vermiculite (for water samples) or equivalent*
- Bubble wrap (optional)
- Ice (if necessary)
- Custody seals
- Chain-of-custody form
- Survey documentation/radiation screening results (if shipping from DOE or radiological sites)
- Orientation labels
- Exempted quantities label
- Consignor/consignee labels

* Check for any client-specific or laboratory requirements related to the use of absorbent packaging materials.

7.5 PACKAGING

The following steps are to be followed when packaging limited quantity samples shipments.

- The cooler is to be surveyed by a qualified radiation control technician to ensure the exterior surfaces do not exceed 0.5 mrem/h on all sides. This survey will be documented and the results reviewed by the qualified shipper.
- Tape any interior opening in the cooler (drain plug) from the inside to ensure control of interior contents. Also, tape the drain plug from the outside of the cooler.
- All sample containers will be properly labeled and the label protected with waterproof tape prior to sampling.
- At a minimum the label must contain:
 - Project name
 - Project number
 - Date and time of sample collection
 - Sample location
 - Sample identification number
 - Collector's initials
- This step is optional; wrap each container in bubble wrap (secure with waterproof tape) to prevent breakage.

PACKAGING AND SHIPPING OF ENVIRONMENTAL SAMPLES

SOP: 2-1

Revision: 1

Date: June 20, 2001

Page 23 of 27

- Place sufficient amount of vermiculite, or approved packaging material, in the bottom of the cooler to absorb any leakage that may occur.
- Place a garbage bag in the cooler.
- Pack the samples appropriately inside the garbage bag (bottles placed upright) to prevent movement during shipment.
- If required, place a sufficient amount of double-bagged ice around the samples to maintain the required temperature during shipment.
- Seal the garbage bag by tying or taping.
- Place a label marked "Radioactive" on the outside of the sealed bag.
- Enclose a notice that includes the name of the consignor or consignee and the following statement: "This package conforms to the conditions and limitations specified in 49 CFR 173.421 for radioactive material, excepted package-limited quantity of material, UN2910.
- The maximum weight of the package shall not exceed 30 kg (66 lbs) for any limited quantity shipment of dangerous goods.
- Secure the chain-of-custody form (placed inside a Ziploc®-type bag) to the interior of the cooler lid.
- If the shipment is from a DOE or other facility, place the results of the radiation screen and cooler/sample survey with the chain-of-custody.
- If a cooler is used, wrap strapping tape or duct tape around both ends of the cooler and around the cooler lid.
- Affix custody seals to opposite sides of the cooler lid. Cover the custody seals with clear waterproof tape.
- Place a label on the front of the cooler with the company name, contact name, phone number, full street address, and state with zip code for both shipper and recipient.
- Affix package orientation labels on two opposite sides of the cooler/package.
- Affix a completed Excepted Quantities label to the side of the cooler/package.
- Secure any marking and labels to the surface of the cooler with clear waterproof tape to prevent accidental removal during shipment.
- An example of the cooler labeling/marketing is shown in Figure 2.

NOTE: No marking or labeling can be obscured by strapping or duct tape.

- Complete the Shipment Quality Assurance Checklist (Appendix B).

NOTE: Except as provided in 49 CFR 173.426, the package will not contain more than 15 grams of ²³⁵U.

NOTE: A declaration of dangerous goods is not required.

PACKAGING AND SHIPPING OF ENVIRONMENTAL SAMPLES

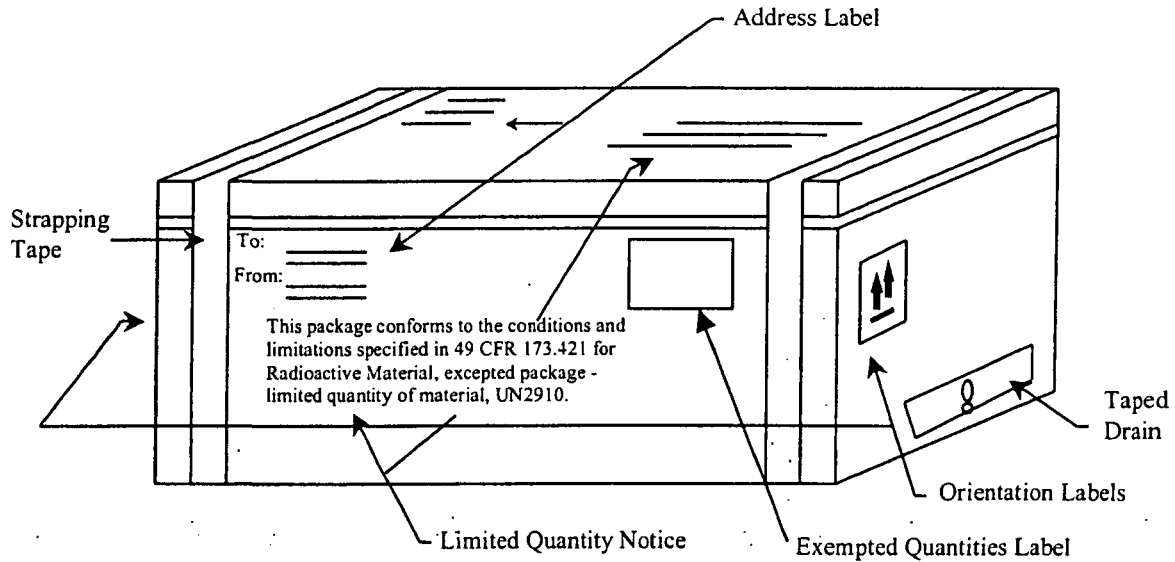
SOP: 2-1

Revision: 1

Date: June 20, 2001

Page 24 of 27

Figure 2 Radioactive Material - Limited Quantity Cooler Marking Example



8.0 REFERENCES

U.S. Environmental Protection Agency, *Sampler's Guide to the Contract Laboratory Program*, EPA/540/P-90/006, December 1990.

U.S. Environmental Protection Agency, Region IV, *Standard Operating Procedures and Quality Assurance Manual*, February 1991.

PACKAGING AND SHIPPING OF ENVIRONMENTAL SAMPLES

SOP: 2-1
Revision: 1
Date: June 20, 2001
Page 25 of 27

APPENDIX A Dangerous Goods and Hazardous Materials Inspection Checklist for Shipping Limited Quantity

Sample Packaging

Yes	No	N/A	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	The VOA vials are wrapped in bubble wrap and placed inside a Ziploc®-type bag.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	The VOA vials are placed into a polyethylene bottle, filled with vermiculite, and tightly sealed.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	The drain plug is taped inside and outside to ensure control of interior contents.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	The samples have been placed inside garbage bags with sufficient bags of ice to preserve samples at 4°C.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	The cooler exceeds the 66-pound limit for limited quantity shipment.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	The garbage bag has been sealed with tape (or tied) to prevent movement during shipment.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	The chain-of-custody has been secured to the interior of the cooler lid.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	The cooler lid and sides have been taped to ensure a seal.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	The custody seals have been placed on both the front and back hinges of the cooler, using waterproof tape.

Air Waybill Completion

Yes	No	N/A	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Section 1 has the shipper's name, company and address; the account number, date, internal billing reference number; and the telephone number where the shipper can be reached.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Section 2 has the recipient's name and company along with a telephone number where they can be reached.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Section 3 has the Bill Sender box checked.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Section 4 has the Standard Overnight box checked.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Section 5 has the Deliver Weekday box checked.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Section 6 has the number of packages and their weights filled out. Was the total of all packages and their weights figured up and added at the bottom of Section 6?
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Under the Transport Details box, the Cargo Aircraft Only box is obliterated, leaving only the Passenger and Cargo Aircraft box.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Under the Shipment Type , the Radioactive box is obliterated, leaving only the Non-Radioactive box.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Under the Nature and Quantity of Dangerous Goods box, the Proper Shipping Name, Class or Division, UN or ID No., Packing Group, Subsidiary Risk, Quantity and Type of Packing, Packing Instructions and Authorization have been filled out for the type of chemical being sent.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	The Name, Place & Date, Signature, and Emergency Telephone number appears at the bottom of the FedEx Airbill.
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	The statement "In accordance with IATA/ICAO" appears in the Additional Handling Information box.

PACKAGING AND SHIPPING OF ENVIRONMENTAL SAMPLES

SOP: 2-1

Revision: 1

Date: June 20, 2001

Page 26 of 27

Proper Shipping Name	Class or Division	UN or ID No.	Packing Group	Sub Risk	Quantity	Packing Instruction	Authorization
Hydrochloric Acid Solution	8	UN1789	II		1 plastic box × 0.5 L	Y809	LTD QTY
Nitric Acid Solution (with less than 20%)	8	UN2031	II		1 plastic box × 0.5 L	Y807	LTD QTY
Sodium Hydroxide Solution	8	UN1824	II		1 plastic box × 0.5 L	Y809	LTD QTY
Sulfuric Acid Solution	8	UN2796	II		1 plastic box × 0.5 L	Y809	LTD QTY
Hexanes	3	UN1208	II		1 plastic box × 1 L	Y305	LTD QTY

Sample Cooler Labeling

Yes No N/A

☐ ☐ ☐

The proper shipping name, UN number, and LTD. QTY. appears on the shipping container.

☐ ☐ ☐

The corresponding hazard labels are affixed on the shipping container; the labels are not obscured by tape.

☐ ☐ ☐

The name and address of the shipper and receiver appear on the top and side of the shipping container.

☐ ☐ ☐

The air waybill is attached to the top of the shipping container.

☐ ☐ ☐

Up Arrows have been attached to opposite sides of the shipping container.

☐ ☐ ☐

Packaging tape does not obscure markings or labeling.

**PACKAGING AND SHIPPING OF
ENVIRONMENTAL SAMPLES**

SOP: 2-1
Revision: 1
Date: June 20, 2001
Page 27 of 27

**APPENDIX B
SHIPMENT QUALITY ASSURANCE CHECKLIST**

Date: _____ Shipper: _____ Destination: _____

Item(s) Description: _____

Radionuclide(s): _____

Radiological Survey Results: surface _____ mrem/hr 1 meter _____

Instrument Used: Mfr: _____ Model: _____

S/N: _____ Cal Date: _____

LIMITED QUANTITY OR INSTRUMENT AND ARTICLE

- | Yes | No | |
|-------|-------|--|
| _____ | _____ | 1. Strong tight package (package that will not leak material during conditions normally incidental to transportation). |
| _____ | _____ | 2. Radiation levels at any point on the external surface of package less than or equal to 0.5 mrem/hr. |
| _____ | _____ | 3. Removable surface contamination less than 20 dpm/100 cm ² (alpha) and 1000 dpm/100 cm ² (beta/gamma). |
| _____ | _____ | 4. Outside inner package bears the marking "Radioactive". |
| _____ | _____ | 5. Package contains less than 15 grams of ²³⁵ U (check yes if ²³⁵ U not present). |
| _____ | _____ | 6. Notice enclosed in or on the package that includes the consignor or consignee and the statement, "This package conforms to the conditions and limitations specified in 49 CFR 173.421 for radioactive material, excepted package-limited quantity of material, UN2910." |
| _____ | _____ | 7. Activity less than that specified in 49 CFR 173.425. Permissible package limit:
Package Quantity: |
| _____ | _____ | 8. On all air shipments, the statement, Radioactive Material, excepted package-limited quantity of material shall be noted on the air waybill. |

Qualified Shipper: _____ Signature: _____

GUIDE TO HANDLING INVESTIGATION-DERIVED WASTE

SOP: 2-2

Revision: 3

Date: June 20, 2001

Page 1 of 9

Prepared: Tim Eggert

Technical Review: Mike Profit

QA Review: Krista Lippoldt

Approved: [Signature]

Signature/Date

Issued: [Signature]

Signature/Date

1.0 OBJECTIVE

This standard operating procedure (SOP) presents guidance for the management of investigation-derived waste (IDW). The primary objectives for managing IDW during field activities include:

- Leaving the site in no worse condition than existed prior to field activities
- Remove wastes which pose an immediate threat to human health or the environment
- Proper handling of onsite wastes that do not require off site disposal or extended above-ground containerization
- Complying with federal, state, and facility applicable or relevant and appropriate requirements (ARARs)
- Careful planning and coordination of IDW management options
- Minimizing the quantity of IDW

2.0 BACKGROUND

2.1 Definitions

Hazardous Waste – Discarded material that is regulated listed waste, or waste that exhibits ignitability, corrosivity, reactivity, or toxicity as defined in 40 CFR 261.3 or state regulations.

Investigation-Derived Wastes (IDWs) - Discarded materials resulting from field activities such as sampling, surveying, drilling, excavations, and decontamination processes that, in present form, possess no inherent value or additional usefulness without treatment. Wastes may be solid, liquid, or gaseous, or multiphase materials that may be classified as hazardous or non-hazardous.

Mixed-Waste - Any material that has been classified as hazardous and radioactive.

Radioactive Wastes – Discarded materials that are contaminated with radioactive constituents with specific activities in concentrations greater than the latest regulatory criteria (i.e., 10 CFR 20).

Treatment, Storage, and Disposal Facility (TSDF) - Permitted facilities which accept hazardous waste shipments for further treatment, storage, and/or disposal. These facilities must be permitted by the U.S. Environmental Protection Agency (EPA) and appropriate state agencies.

GUIDE TO HANDLING INVESTIGATION-DERIVED WASTE

SOP: 2-2
Revision: 3
Date: June 20, 2001
Page 2 of 9

2.2 Discussion

Field investigation activities result in the generation of waste materials that may be characterized as a hazardous or radioactive waste. IDWs may include drilling muds, cuttings, and purge water from test pit and well installation; purge water, soil, and other materials from collection of samples; residues from testing of treatment technologies and pump and treat systems; personal protective equipment (PPE); solutions (aqueous or otherwise) used to decontaminate non-disposable protective clothing and equipment; and other wastes or supplies used in sampling and testing potentially hazardous or radiologically contaminated material.

NOTE: The client's representatives may not be aware of all potential contaminants. The management of IDW must comply with regulatory requirements that are applicable.

3.0 RESPONSIBILITIES

Site Manager - The site manager is responsible for ensuring that all IDW procedures are conducted in accordance with this SOP. The site manager is also responsible for ensuring that handling of IDW is in accordance with site-specific requirements.

Project Manager - The project manager is responsible for identifying site-specific requirements for the disposal of IDW in accordance with federal, state, and/or facility requirements.

Field Crew Members - Field crew members are responsible for implementing this SOP and communicating any unusual or unplanned condition to the project manager's attention.

4.0 REQUIRED EQUIPMENT

Equipment required for IDW containment will vary according to site-specific/client requirements. Management decisions concerning the necessary equipment required should consider: containment method, sampling, labeling, maneuvering, and storage (if applicable). Equipment must be on site and inspected before commencing work.

4.1 IDW Containment Devices

The appropriate containment device (drums, tanks, etc.) will depend on site- or client-specific requirements and the ultimate disposition of the IDW. Typical IDW containment devices can include:

- Plastic sheeting (polyethylene) with a minimum thickness of 20 millimeters
- Department of Transportation (DOT) approved steel containers
- Bulk storage tanks comprised of polyethylene or steel

GUIDE TO HANDLING INVESTIGATION-DERIVED WASTE

SOP: 2-2

Revision: 3

Date: June 20, 2001

Page 3 of 9

Containment of IDW should be segregated by waste type (i.e., solid or liquid, corrosive or flammable, etc.) and source location. Volume of the appropriate containment device should be site-specific.

4.2 IDW Container Labeling

A "Waste Container" or "IDW Container" label or indelible marking should be applied to each container. Labeling or marking requirements for onsite IDW not expected to be transported off site are:

- Labels and markings that contain the following information: project name; generation date; location of waste origin; container identification number; sample number (if applicable); contents (drill cuttings, purge water, PPE, etc.).
- Each label or marking will be applied to the upper one-third of the container at least twice, on opposite sides.
- Containers that are five-gallons or less may only require one label or set of markings.
- Labels or markings will be positioned on a smooth part of the container. The label must not be affixed across container bungs, seams, ridges, or dents.
- Labels must be constructed of a weather-resistive material with markings made with a permanent marker or paint pen and capable of enduring the expected weather conditions. If markings are used, the color must be easily distinguishable from the drum color.
- Labels will be secured in a manner to ensure the label remains affixed to the container.

Labeling or marking requirements for IDW expected to be transported off site must be in accordance with the requirements of 49 CFR 172.

4.3 IDW Container Movement

Staging areas for IDW containers should be predetermined and in accordance with site-specific and/or client requirements. Arrangements should be made prior to field mobilization as to the methods and personnel required to safely transport IDW containers to the staging area. Transportation off site onto a public roadway is prohibited unless 49 CFR 172 requirements are met.

4.4 IDW Container Storage

Containerized IDW should be staged pending chemical analysis or further onsite treatment. Staging areas and bulk storage procedures are to be determined according to site-specific requirements. Containers are to be stored in such a fashion that the labels can be easily read. A secondary/spill container must be provided as appropriate.

5.0 PROCEDURES

The three general options for managing IDW are (1) collection and onsite disposal; (2) collection for off site disposal; and (3) collection and interim management. Attachment 1 summarizes media-

GUIDE TO HANDLING INVESTIGATION-DERIVED WASTE

SOP: 2-2

Revision: 3

Date: June 20, 2001

Page 4 of 9

specific information on generation processes and management options. The option selected should take into account the following factors:

- Type (soil, sludge, liquid, debris), quantity, and source of IDW
- Risk posed by managing the IDW on site
- Compliance with regulatory requirements
- IDW minimization and consistency with the IDW remedy and the site remedy

In all cases the client should approve the plans for IDW. Formal plans for the management of IDW must be prepared as part of a work plan or separate document.

5.1 Onsite Disposal

5.1.1 Soil/Sludge/Sediment

The options for handling soil/sludge/sediment IDW are as follows:

1. Return to boring, pit, or source immediately after generation as long as returning the media to these areas will not increase site risks (e.g., the contaminated soil will not be replaced at a greater depth than where it was originally so that it will not contaminate "clean" areas).
2. Spread around boring, pit, or source within the area of contamination (AOC) as long as returning the media to these areas will not increase site risks (e.g., direct contact with surficial contamination).
3. Consolidate in a pit within the AOC as long as returning the media to these areas will not increase site risks (e.g., the contaminated soil will not be replaced at a greater depth than where it was originally so that it will not contaminate "clean" areas).
4. Send to onsite TSDF - may require analytical analysis prior to treatment/disposal.

NOTE: These options may require client and/or regulatory approval.

5.1.2 Aqueous Liquids

The options for handling aqueous liquid IDW are as follows:

1. Discharge to surface water, only when IDW is not contaminated.
2. Discharge to ground surface close to the well, only if soil contaminants will not be mobilized in the process and the action will not contaminate clean areas. If IDW from the sampling of background up-gradient wells is not a community concern nor associated with soil contamination, this presumably uncontaminated IDW may be released on the ground around the well.

GUIDE TO HANDLING INVESTIGATION-DERIVED WASTE

SOP: 2-2

Revision: 3

Date: June 20, 2001

Page 5 of 9

3. Discharge to sanitary sewer.
4. Send to onsite TSDF - may require analysis prior to treatment/disposal.

NOTE: These options may require analytical results to obtain client and/or regulatory approval.

5.1.3 Disposable PPE

The options for handling disposable PPE are as follows:

1. Double-bag contents in non-transparent trash bags and place in onsite industrial dumpster, only if PPE is not contaminated.
2. Containerize, label, and send to onsite TSDF - may require analysis prior to treatment/disposal.

5.2 Off Site Disposal

Before sending to an offsite TSDF, analysis may be required. Also, manifests are required. Arrangements must be made with the client responsible for the site; it is CDM Federal's policy not to sign manifests. The TSDF and transporter must be permitted for the respective wastes.

5.2.1 Soil/Sludge/Sediment

When the final site remedy requires off site treatment and disposal, the IDW may be stored (e.g., drummed, covered in a waste pile) or returned to its source until final disposal. The management option selected should take into account the potential for increased risks, applicable regulations, and other relevant site-specific factors (e.g., weather, storage space, and public concern/perceptions).

5.2.2 Aqueous Liquids

When the final site remedy requires off site treatment and disposal, the IDW may be stored (e.g., mobile tanks or drums) until final disposal. The management option selected should take into account the potential for increased risks, applicable regulations, and other relevant site-specific factors (e.g., weather, storage space, and public concern/perceptions).

5.2.3 Disposable PPE

When the final site remedy requires off site treatment disposal, the IDW may be containerized and stored. The management option selected should take into account potential for increased risks, applicable regulations, and other relevant site-specific factors (e.g., weather, storage space, and public concern/perceptions).

GUIDE TO HANDLING INVESTIGATION-DERIVED WASTE

SOP: 2-2
Revision: 3
Date: June 20, 2001
Page 6 of 9

5.3 Interim Measures

All interim measures must be approved by the client and regulatory agencies.

1. Storing IDW on site until the final action may be practical in the following situations:
 - A. Returning wastes (especially sludges and soils) to their onsite source area would require re-excavation for disposal in the final remediation alternative.
 - B. Interim storage in containers may be necessary to provide adequate protection to human health and the environment.
 - C. Off site disposal options may trigger land disposal regulations under the Resource Conservation and Recovery Act (RCRA). Storing IDW until the final disposal of all wastes from the site will eliminate the need to address this issue more than once.
 - D. Interim storage may be necessary to provide time for sampling and analysis.
2. Segregate and containerize all waste for future treatment and/or disposal.
 - A. Containment options for soil/sludge/sediment may include drums or covered waste piles in AOC.
 - B. Containment options for aqueous liquids may include mobile tanks or drums.
 - C. Containment options for PPE may include drums or roll-off boxes.

6.0 RESTRICTIONS/LIMITATIONS

SITE MANAGERS SHOULD DETERMINE THE MOST APPROPRIATE DISPOSAL OPTION FOR AQUEOUS LIQUIDS ON A SITE-SPECIFIC BASIS. Parameters to consider, especially when determining the level of protection, include the volume of IDW, the contaminants present in the groundwater, the presence of contaminants in the soil at the site, whether the groundwater or surface water is a drinking water supply, and whether the groundwater plume is contained or moving. Special disposal/handling may be needed for drilling fluids because they may contain significant solid components.

Disposable sampling materials, disposable PPE, decontamination fluids, etc. will always be managed on a site-specific basis. **UNDER NO CIRCUMSTANCES SHOULD THESE TYPES OF MATERIALS BE BROUGHT BACK TO THE OFFICE OR WAREHOUSE.**

GUIDE TO HANDLING INVESTIGATION-DERIVED WASTE

SOP: 2-2
Revision: 3
Date: June 20, 2001
Page 7 of 9

7.0 REFERENCES

Environmental Resource Center, *Hazardous Waste Management Compliance Handbook*, Van Nostrand Reinhold, 1992.

Institute of Hazardous Materials Management, *Handbook on Hazardous Materials Management*, 4th Ed., 1992.

U. S. Environmental Protection Agency, Region IV, *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual*, May 1996 and 1997 revisions.

U. S. Environmental Protection Agency, *A Compendium of Superfund Field Operations Methods*, EPA/540/P-87/001.1, 1987.

U. S. Environmental Protection Agency, *Management of Investigation-Derived Wastes During Site Inspections*, EPA/540/G-91/009, May 1991.

U. S. Environmental Protection Agency, *Low-Level Mixed Waste: A RCRA Perspective for NRC Licensees*, EPA/530-SW-90-057, August 1990.

U. S. Environmental Protection Agency, *Guide to Management of Investigation-Derived Wastes*, 9345.3-03FS, January 1992.

GUIDE TO HANDLING INVESTIGATION-DERIVED WASTE

SOP: 2-2
Revision: 3
Date: June 20, 2001
Page 8 of 9

ATTACHMENT 1 IDW MANAGEMENT OPTIONS

TYPE OF IDW	GENERATION PROCESSES	MANAGEMENT OPTIONS
Soil	<ul style="list-style-type: none"> • Well/Test pit installations • Borehole drilling • Soil sampling 	<p>Onsite Disposal</p> <ul style="list-style-type: none"> • Return to boring, pit, or source immediately after generation • Spread around boring, pit, or source within the AOC • Consolidate in a pit (within the AOC) • Send to onsite TSDF <p>Off site Disposal</p> <ul style="list-style-type: none"> • Client to send to off site TSDF <p>Interim Management</p> <ul style="list-style-type: none"> • Store for future treatment and/or disposal
Sludge/Sediment	<ul style="list-style-type: none"> • Sludge pit/sediment sampling 	<p>Onsite Disposal</p> <ul style="list-style-type: none"> • Return to boring, pit, or source immediately after generation • Send to onsite TSDF <p>Off site Disposal</p> <ul style="list-style-type: none"> • Client to send to off site TSDF <p>Interim Management</p> <ul style="list-style-type: none"> • Store for future treatment and/or disposal
Aqueous liquids (groundwater, surface water, drilling fluids, wastewaters)	<ul style="list-style-type: none"> • Well installation/development • Well purging during sampling • Groundwater discharge during pump tests • Surface water sampling • Waste water sampling 	<p>Onsite Disposal</p> <ul style="list-style-type: none"> • Pour onto ground close to well (non-hazardous waste) • Discharge to sewer • Send to onsite TSDF <p>Off site Disposal</p> <ul style="list-style-type: none"> • Client to send to off site commercial treatment unit • Client to send to publicly owned treatment works (POTW) <p>Interim Management</p> <ul style="list-style-type: none"> • Store for future treatment and/or disposal
Decontamination fluids	<ul style="list-style-type: none"> • Decontamination of PPE and equipment 	<p>Onsite Disposal</p> <ul style="list-style-type: none"> • Send to onsite TSDF • Evaporate (for small amounts of low contamination organic fluids) • Discharge to ground surface <p>Off site Disposal</p> <ul style="list-style-type: none"> • Client to send to off site TSDF • Discharge to sewer <p>Interim Management</p> <ul style="list-style-type: none"> • Store for future treatment and/or disposal

GUIDE TO HANDLING INVESTIGATION-DERIVED WASTE

SOP: 2-2
Revision: 3
Date: June 20, 2001
Page 9 of 9

ATTACHMENT 1 IDW MANAGEMENT OPTIONS

TYPE OF IDW	GENERATION PROCESSES	MANAGEMENT OPTIONS
Disposable PPE and Sampling Equipment	<ul style="list-style-type: none">• Sampling procedures or other onsite activities	Onsite Disposal <ul style="list-style-type: none">• Place in onsite industrial dumpster• Send to onsite TSDF Off site Disposal <ul style="list-style-type: none">• Client to send to off site TSDF Interim Management <ul style="list-style-type: none">• Store for future treatment and/or disposal

Adapted from U.S. Environmental Protection Agency, Guide to Management of Investigation-Derived Wastes, 9345-03FS, January 1992.

FIELD LOGBOOK CONTENT AND CONTROL

SOP 4-1

Revision: 4

Date: June 20, 2001

Page 1 of 5

Prepared: Del Baird

Technical Review: Larry Davidson

QA Review: David O. Johnson

Approved: [Signature]

Signature/Date

Issued: Rosemary J. Austin 6/29/01

Signature/Date

1.0 OBJECTIVE

The objective of this standard operating procedure (SOP) is to set CDM Federal criteria for content entry and form of field logbooks. Field logbooks are an essential tool to document field activities for historical and legal purposes.

2.0 BACKGROUND

2.1 Definitions

Biota - The flora and fauna of a region.

Magnetic Declination Corrections - Compass adjustments to correct for the angle between magnetic north and geographical meridians.

2.2 Discussion

Information recorded in field logbooks includes field team names, observations, data, calculations, date/time, weather, and description of the data collection activity, methods, instruments, and results. Additionally, the logbook may contain deviations from plans and descriptions of wastes, biota, geologic material, and site features including sketches, maps, or drawings as appropriate.

3.0 RESPONSIBILITIES

Field Team Leader (FTL) - The FTL is responsible for ensuring that the format and content of data entries are in accordance with this procedure.

Site Personnel - All CDM Federal employees who make entries in field logbooks during onsite activities are required to read this procedure prior to engaging in this activity. The FTL will assign field logbooks to site personnel who will be responsible for their care and maintenance. Site personnel will return field logbooks to the records file at the end of the assignment.

FIELD LOGBOOK CONTENT AND CONTROL

SOP 4-1

Revision: 4

Date: June 20, 2001

Page 2 of 5

4.0 REQUIRED EQUIPMENT

- Site-specific plans
- Field notebook
- Indelible black or blue ink pen
- Ruler or similar scale

5.0 PROCEDURES

5.1 Preparation

In addition to this SOP, site personnel responsible for maintaining logbooks must be familiar with all procedures applicable to the field activity being performed. These procedures should be consulted as necessary to obtain specific information about equipment and supplies, health and safety, sample collection, packaging, decontamination, and documentation. These procedures should be located at the field office.

Field logbooks shall be bound with lined, consecutively numbered pages. All pages must be numbered prior to initial use of the logbook. Prior to use in the field, each logbook will be marked with a specific document control number issued by the document control administrator, if required by the contract quality implementation plan (QIP). Not all contracts require document control numbers. The following information shall be recorded on the cover of the logbook:

- Field logbook document control number.
- Activity (if the logbook is to be activity-specific) and location.
- Name of CDM Federal contact and phone number(s).
- Start date.
- In specific cases, special logbooks may be required (e.g., waterproof paper for storm water monitoring).

The first few (approximately five) pages of the logbook will be reserved for a table of contents (TOC). Mark the first page with the heading and enter the following:

TABLE OF CONTENTS

Date/Description	Page
(Start Date)/Reserved for TOC	1-5

The remaining pages of the table of contents will be designated as such with "TOC" written on the top center of each page.

FIELD LOGBOOK CONTENT AND CONTROL

SOP 4-1

Revision: 4

Date: June 20, 2001

Page 3 of 5

5.2 Operation

The following is a list of requirements that must be followed when using a logbook:

- Record work, observations, quantities of materials, calculations, drawings, and related information directly in the logbook. If data collection forms are specified by an activity-specific plan, this information need not be duplicated in the logbook. However, any forms used to record site information must be referenced in the logbook.
- Do not start a new page until the previous one is full or has been marked with a single diagonal line so that additional entries cannot be made. Use both sides of each page.
- Do not erase or blot out any entry at any time. Indicate any deletion by a single line through the material to be deleted. Initial and date each deletion. Take care to not obliterate what was written previously.
- Do not remove any pages from the book.

Specific requirements for field logbook entries include:

- Initial and date each page.
- Sign and date the final page of entries for each day.
- Initial and date all changes.
- Multiple authors must sign out the logbook by inserting the following:

Above notes authored by:

- (Sign name)
- (Print name)
- (Date)

- A new author must sign and print his/her name before additional entries are made.
- Draw a diagonal line through the remainder of the final page at the end of the day.
- Record the following information on a daily basis:
 - Date and time
 - Name of individual making entry
 - Names of field team and other persons on site
 - Description of activity being conducted including station or location (i.e., well, boring, sampling location number) if appropriate
 - Weather conditions (i.e., temperature, cloud cover, precipitation, wind direction, and speed) and other pertinent data
 - Level of personal protection to be used
 - Serial numbers of instruments
 - Required calibration information
 - Serial/tracking numbers on documentation (e.g., carrier air bills)

FIELD LOGBOOK CONTENT AND CONTROL

SOP 4-1

Revision: 4

Date: June 20, 2001

Page 4 of 5

Entries into the field logbook shall be preceded with the time (written in military units) of the observation. The time should be recorded frequently and at the point of events or measurements that are critical to the activity being logged. All measurements made and samples collected must be recorded unless they are documented by automatic methods (e.g., data logger) or on a separate form required by an operating procedure. In these cases, the logbook must reference the automatic data record or form.

At each station where a sample is collected or an observation or measurement made, a detailed description of the location of the station is required. Use a compass (include a reference to magnetic declination corrections), scale, or nearby survey markers, as appropriate. A sketch of station location may be warranted. All maps or sketches made in the logbook should have descriptions of the features shown and a direction indicator. It is preferred that maps and sketches be oriented so that north is toward the top of the page. Maps, sketches, figures, or data that will not fit on a logbook page should be referenced and attached to the logbook to prevent separation.

Other events and observations that should be recorded include:

- Changes in weather that impact field activities.
- Deviations from procedures outlined in any governing documents. Also record the reason for any noted deviation.
- Problems, downtime, or delays.
- Upgrade or downgrade of personal protection equipment.

5.3 Post-Operation

To guard against loss of data due to damage or disappearance of logbooks, completed pages shall be periodically photocopied (weekly, at a minimum) and forwarded to the field or project office. Other field records shall be photocopied and submitted regularly and as promptly as possible to the office. When possible, electronic media such as disks and tapes should be copied and forwarded to the project office.

At the conclusion of each activity or phase of site work, the individual responsible for the logbook will ensure that all entries have been appropriately signed and dated, and that corrections were made properly (single lines drawn through incorrect information, then initialed and dated). The completed logbook shall be submitted to the records file.

FIELD LOGBOOK CONTENT AND CONTROL

SOP 4-1

Revision: 4

Date: June 20, 2001

Page 5 of 5

6.0 RESTRICTIONS/LIMITATIONS

Field logbooks constitute the official record of onsite technical work, investigations, and data collection activities. Their use, control, and ownership are restricted to activities pertaining to specific field operations carried out by CDM Federal personnel and their subcontractors. They are documents that may be used in court to indicate dates, personnel, procedures, and techniques employed during site activities. Entries made in these notebooks should be factual, clear, precise, and non-subjective. Field logbooks, and entries within, are not to be utilized for personal use.

7.0 REFERENCES

Sandia National Laboratories, *Procedure for Preparing, Sampling and Analysis Plan, Site-Specific Sampling Plan, and Field Operating Procedures*, QA-02-03, Albuquerque Environmental Program Department 3220, Albuquerque, New Mexico, 1991.

Sandia National Laboratories, Division 7723, *Field Operation Procedure for Field Logbook Content and Control*, Environmental Restoration Department, Albuquerque, New Mexico, 1992.

WELL DEVELOPMENT AND PURGING

SOP: 4-3

Revision: 3

Date: June 20, 2001

Page 1 of 4

Prepared: Del Baird

Technical Review: Peggy Bloisa

QA Review: David O. Johnson

Approved: [Signature]

Issued: [Signature]

Signature/Date

Signature/Date

1.0 OBJECTIVE

The purpose of this standard operating procedure (SOP) is to define the procedural requirements for well development and purging.

2.0 BACKGROUND

Monitoring wells are developed to remove skin (i.e., near-well-bore formation damage) and to settle and remove fines from the filter pack. Wells should not be developed for 24 hours after completion when a cement bentonite grout is used to seal the annular space; however, wells may be developed before grouting if conditions warrant. Wells are purged immediately before groundwater sampling to remove stagnant water and to sample representative groundwater conditions. Wells should be sampled within 3 hours of purging (optimum) to 24 hours after purging (maximum, for low recharge conditions).

2.1 Associated Procedures

- CDM Federal SOP 1-6, Water Level Measurement
- CDM Federal SOP 4-5, Field Equipment Decontamination at Non-radioactive Sites

3.0 RESPONSIBILITIES

Site Manager - The site manager is responsible for ensuring that field personnel are trained in the use of this procedure and for verifying that development and purging are carried out in accordance with this procedure.

Field Team Leader - The field team leader is responsible for complying with this procedure.

4.0 REQUIRED EQUIPMENT

- Pump, pump tubing, or bailer and rope or wire line
- Power source (e.g., generator), if required
- Water-level meter or weighted surveyor's tape
- Temperature, conductivity, pH, and turbidity meters

WELL DEVELOPMENT AND PURGING

SOP: 4-3

Revision: 3

Date: June 20, 2001

Page 2 of 4

- Personal protective equipment as specified in the site-specific health and safety plan
- Decontamination supplies, as required, according to CDM Federal SOP 4-5 Field Equipment Decontamination at Nonradioactive Sites
- Disposal drums, if required
- Photoionization detector (PID) or equivalent as specified in site-specific health and safety plan

5.0 PROCEDURES

5.1 Well Development

The following steps must be followed when developing wells:

1. Don personal protective clothing and equipment as specified in the site-specific health and safety plan.
2. Open the well cover and check the condition of the wellhead, including the condition of the surveyed reference mark, if any.
3. Monitor wellhead, using a PID or equivalent, as soon as well cover is removed according to health and safety requirements.
4. Determine the depth to static water level and depth to bottom of the casing.
5. Prepare the necessary equipment for developing the well. There are a number of techniques that can be used to develop a well. Some of the more common methods are bailing, overpumping, backwashing, mechanical surging, surge and pump, and high-velocity jetting. All of these procedures are acceptable; however, final approval of the development method rests with the appropriateness of a specific method to the site and the client.
6. For screened intervals longer than 10 feet, develop the well in 2- or 3-foot intervals from bottom to top. This will ensure proper packing of the filter pack.
7. Continue well development until produced water is clear and free of suspended solids, as determined by a turbidity meter or when pH, conductivity, and temperature have stabilized. Record pertinent data in the field logbook and on appropriate well development forms. Remove the pump assembly or bailers from the well, decontaminate (if required), and clean up the area. Lock the well cover before leaving. Dispose of development water as required by the site-specific plans.

5.2 Volumetric Method of Well Purging

The following steps should be followed when purging a well by the volumetric method:

1. Don personal protective clothing and equipment as specified in the site-specific health and safety plan.
2. Open the well cover and check the condition of the wellhead, including the condition of the surveyed reference mark, if any.
3. Monitor wellhead, using a PID or equivalent, as soon as well cover is removed according to health and safety requirements.

WELL DEVELOPMENT AND PURGING

SOP: 4-3

Revision: 3

Date: June 20, 2001

Page 3 of 4

4. Determine the depth to static water level and depth to bottom of well casing according to CDM Federal SOP 1-6 Water Level Measurement. Calculate the volume of water within the well bore using the following formula (or equivalent):

$$7.4805 \left[\frac{D^2 \pi}{(4)} \right] dH = \text{volume (in gallons)},$$

where

D = casing diameter in feet. (NOTE: This equation is used for grouted wells with short screens. For wells with long screens and/or ungrouted wells, the D = borehole diameter in feet).

dH = the distance from well bottom to static water level in feet

$\pi = 3.1416$

NOTE: Record all data and calculations in the field logbook.

5. Prepare the pump and tubing, or bailer, and lower it into the casing.
6. Remove the number of well volumes specified in the site-specific plans. Generally, three to five well volumes will be required. Conductivity, pH, and temperature should be measured and recorded, if required by site-specific plans. In low recharge aquifers, the well commonly will be pumped or bailed to dryness before three well volumes of water are removed. If this is the case, there is no need to continue with purging operations. Record pertinent data in the field logbook.
7. Remove the pump assembly or bailer from the well, decontaminate it (if required), and clean up the site. Lock the well cover before leaving. Dispose of development water as required by the site-specific plan.

5.3 Indicator Parameter Method of Well Purging

1. Don personal protective clothing and equipment as specified in the site-specific health and safety plan.
2. Open the well cover and check the condition of the wellhead, including the condition of the surveyed reference mark, if any.
3. Monitor wellhead, using a PID or equivalent, as soon as well cover is removed according to health and safety requirements.
4. Determine the depth to static water level and depth to bottom. Set up surface probe(s), (e.g., pH, conductivity) at the discharge orifice or dedicated probe port of the pump assembly or within the flow-through chamber. Allow probe(s) to equilibrate according to manufacturer's specifications. Record the equilibrated readings in the field logbook.
5. Assemble the pump and tubing, or bailer, and lower into the casing.
6. Begin pumping or bailing the well. Record indicator parameter readings for every purge volume. Maintain a record of the approximate volumes of water produced.
7. Continue pumping or bailing until indicator parameter readings remain stable within +10 percent for three consecutive recording intervals, or in accordance with site-specific plans. Purging should continue until the discharge stream is clear or turbidity becomes asymptotic-low or meets project requirements. In a low recharge aquifer, the well may pump or bail to

WELL DEVELOPMENT AND PURGING

SOP: 4-3

Revision: 3

Date: June 20, 2001

Page 4 of 4

dryness before indicator parameters stabilize. In this case, there is no need to continue purging. Record pertinent data in the field logbook.

8. Remove the pump assembly or bailer from the well, decontaminate (if required), and clean up the site. Lock the well cover before leaving. Dispose of development water as required by the site-specific plans.

6.0 RESTRICTIONS/LIMITATIONS

Where flammable, free, or emulsified product is expected, or known to exist on, or in groundwater, use intrinsically safe electrical devices only and place portable power sources (e.g., generators) 50 feet or further from the wellhead and disposal drums.

7.0 REFERENCES

U.S. Department of Energy, Hazardous Waste Remedial Actions Program, *Quality Control Requirements For Field Methods*, DOE/HWP-69/R2, September 1996.

U.S. Department of Energy, Hazardous Waste Remedial Actions Program, *Standard Operating Procedures For Site Characterizations*, DOE/HWP-100/R2, September 1996 or current revision.

U.S. Environmental Protection Agency, *A Compendium of Superfund Field Operations Methods*, EPA/540/P-87/001, OSWER Directive 9355.6-14, December 1987.

FIELD EQUIPMENT DECONTAMINATION AT NONRADIOACTIVE SITES

SOP: 4-5

Revision: 5

Date: December 11, 2002

Page 1 of 9

Prepared: Steven Fundingsland

Technical Review: Laura Spichal

QA Review: Matt Brookshire

Approved: [Signature] 12/18/02

Issued: [Signature] 12/10/02

Signature/Date

Signature/Date

1.0 OBJECTIVE

The objective of this standard operating procedure (SOP) is to describe the procedures required for decontamination of field equipment.

2.0 BACKGROUND

2.1 Definitions

Clean - Free of visible contamination and when decontamination has been completed in accordance with this SOP.

Cross-Contamination - The transfer of contaminants through equipment or personnel from the contamination source to less contaminated or non-contaminated samples or areas.

Decontamination - The process of rinsing or otherwise cleaning the surfaces of equipment to rid them of contaminants and to minimize the potential for cross contamination of samples or exposure of personnel.

2.2 Discussion

Decontamination of field equipment is necessary to ensure acceptable quality of samples by preventing cross contamination. Further, decontamination reduces health hazards and prevents the spread of contaminants off-site.

3.0 RESPONSIBILITIES

Field Team Leader - The Field Team Leader (FTL) ensures that field personnel are trained in the performance of this procedure and that decontamination is conducted in accordance with this procedure. The FTL may also be required to collect and document rinsate samples to provide quantitative verification that these procedures have been correctly implemented.

FIELD EQUIPMENT DECONTAMINATION AT NONRADIOACTIVE SITES

SOP: 4-5

Revision: 5

Date: December 11, 2002

Page 2 of 9

4.0 REQUIRED EQUIPMENT

- Stiff-bristle scrub brushes
- Plastic buckets and troughs
- Laboratory-grade detergent, low phosphate (Alconox™, Liquinox™ or similar)
- Nalgene or Teflon Sprayers or wash bottles or 2- to 5-gallon, manual-pump sprayer (pump sprayer material must be compatible with the solution used)
- Plastic sheeting
- Disposable wipes, rags or paper towels
- Potable water and/or de-ionized water of American Society for Testing and Materials (ASTM) Type II or better, as defined by ASTM Standard Specification for Reagent Water, Standard D 1193-77 (re-approved 1983)*
- Gloves, safety glasses, and other protective clothing as specified in the site-specific health and safety plan
- High-pressure pump with soap dispenser or steam-spray unit (for large equipment only)
- Appropriate decontamination solutions pesticide grade or better and traceable to a source (e.g. 10% and/or 1% nitric acid (HNO₃), acetone, methanol, isopropanol, hexane)
- Tools for equipment assembly and disassembly (as required)
- 55-gallon drums or tanks (as required)
- Pallets for drums or tanks holding decontamination water (as required)

* Potable water may be required to be tested for contaminants before use. Check field plan for requirements. ASTM Type II water will include a certificate of quality.

5.0 PROCEDURES

All reusable equipment (non-dedicated) used to collect, handle, or measure samples will be decontaminated before coming into contact with any sample. Decontamination of equipment will occur either at a central decontamination station or at portable decontamination stations set up at the sampling location, drill site, or monitoring well location. The centrally-located decontamination station will include an appropriately sized bermed and lined area on which equipment decontamination will occur and shall be equipped with a collection system and storage vessels. In certain circumstances, berming is not required when small quantities of water are being generated and for some short duration field activities (i.e., pre-remedial sampling). Equipment should be transported to the decontamination station in a manner to prevent cross-contamination of equipment and/or area. Precautions taken may include enclosing augers in plastic wrap while being transported on a flatbed truck.

The decontamination area will be constructed so that contaminated water is either collected directly into appropriate containers (5-gallon buckets or steel wash tubs) or within the berms of the

FIELD EQUIPMENT DECONTAMINATION AT NONRADIOACTIVE SITES

SOP: 4-5

Revision: 5

Date: December 11, 2002

Page 3 of 9

decontamination area which then drains into a collection system. Water from the collection system will be transferred into 55-gallon drums or portable tanks for storage. Typically, decontamination water will be staged until sampling results or waste characterization results are obtained and evaluated and the proper disposition of the waste is determined. The exact procedure for decontamination waste disposal should be discussed in the field plan. Also, decontamination fluids, such as solvents, may need to be segregated from other investigation-derived wastes.

All items that will come into contact with potentially contaminated media will be decontaminated before use and between sampling and/or drilling locations. If decontaminated items are not immediately used, they will be covered either with clean plastic or aluminum foil depending on the size of the item. All decontamination procedures for the equipment being used are as follows:

General Guidelines

- Potable and de-ionized water should be free of all contaminants of concern. Following the field plan, analytical data from the water source may be required. If required, either existing analytical data from the water source supplier (i.e., municipality, bottled water company, de-ionized water producer) may be obtained or chemical testing may be performed on the selected source.
- Soap will be a low phosphate detergent.
- Sampling equipment that has come into contact with oil and grease will be cleaned with methanol or other approved alternative to remove the oily material. This may be followed by a hexane rinse and then another methanol rinse. Regulatory or client requirements regarding solvent use will be stated in the field plan.
- All solvents will be pesticide grade or better and traceable to a source. The corresponding lot numbers will be recorded in the appropriate logbook.
- Decontaminated equipment will be allowed to air dry before being used.
- Documentation for all cleaning will be recorded in the appropriate logbook.
- Gloves, boots, safety glasses, and any other personnel protective clothing and equipment will be used as specified in the site-specific health and safety plan.

FIELD EQUIPMENT DECONTAMINATION AT NONRADIOACTIVE SITES

SOP: 4-5

Revision: 5

Date: December 11, 2002

Page 4 of 9

5.1 Heavy Equipment Decontamination

Heavy equipment includes drilling rigs and backhoes. Follow these steps when decontaminating this equipment:

1. Establish a decontamination area with berms that is large enough to fully contain the equipment to be cleaned. If available, an existing wash pad or appropriate paved and bermed area may be utilized; otherwise, use one or more layers of heavy plastic sheeting to cover the ground surface and berms. All decontamination pads should be upwind of the area under investigation.
2. With the rig in place, spray areas (rear of rig or backhoe) exposed to contaminated soils using a hot water high-pressure sprayer. Be sure to spray down all surfaces, including the undercarriage.
3. Use brushes, low phosphate detergent and potable water to remove dirt whenever necessary.
4. Remove equipment from the decontamination pad and allow it to air dry before returning it to the work site.
5. Record equipment type, date, time, and method of decontamination in the appropriate logbook.
6. After decontamination activities are completed, collect all contaminated wastewater, plastic sheeting, and disposable gloves, boots, and clothing in separate containers or receptacles. All receptacles containing contaminated items must be properly labeled for disposal as detailed in the field plan. Liquids and solids must be drummed separately.

5.2 Downhole Equipment Decontamination

Downhole equipment decontamination includes hollow-stem augers, drill pipes, casings, screens, etc. Follow these steps when decontaminating this equipment:

1. Set up a centralized decontamination area, if possible. This area should be set up to collect contaminated rinse waters and to minimize the spread of airborne spray.
2. Set up a "clean" area upwind of the decontamination area to receive cleaned equipment for air-drying. At a minimum, clean plastic sheeting must be used to cover the ground, tables, or other surfaces on which decontaminated equipment is to be placed. All decontamination pads should be upwind of any areas under investigation.

FIELD EQUIPMENT DECONTAMINATION AT NONRADIOACTIVE SITES

SOP: 4-5

Revision: 5

Date: December 11, 2002

Page 5 of 9

3. Place the object to be cleaned on aluminum foil or plastic-covered wooden sawhorses or other supports.
4. Using low phosphate detergent and potable water in the hot water high-pressure sprayer (or steam unit), spray the contaminated equipment. Aim downward to avoid spraying outside the decontamination area. Be sure to spray inside corners and gaps especially well. Use a brush, if necessary, to dislodge dirt.
5. If using soapy water, rinse the equipment using clean, potable water. If using hot water, the rinse step is not necessary if the hot water does not contain a detergent. If the hot water contains a detergent, this final clean water rinse is required.
6. Using the manual-pump sprayer, rinse the equipment thoroughly with de-ionized water (ASTM Type II or better).
7. Remove the equipment from the decontamination area and place in a clean area upwind to air dry.
8. Record equipment type, date, time, and method of decontamination in the appropriate logbook.
9. After decontamination activities are completed, collect all contaminated wastewaters, plastic sheeting, and disposable gloves, boots, and clothing in separate containers or receptacles. All receptacles containing contaminated items must be properly labeled for disposal. Liquids and solids must be drummed separately.

5.3 Sampling Equipment Decontamination

Sampling equipment includes split spoons, spatulas, and bowls used for sample homogenization that directly contact sample media. Follow these steps when decontaminating this equipment:

1. Set up a decontamination line on plastic sheeting. The decontamination line should progress from "dirty" to "clean" and have an area located upwind for drying decontaminated equipment. At a minimum, clean plastic sheeting must be used to cover the ground, tables, or the surfaces on which decontaminated equipment is to be placed for drying.
2. Before washing, disassemble any items that might trap contaminants internally. Do not reassemble these items until decontamination and air-drying are complete. Wash items thoroughly in a bucket of low phosphate detergent and potable water. Use a stiff-bristle brush to dislodge any gross contamination (soil or debris).

FIELD EQUIPMENT DECONTAMINATION AT NONRADIOACTIVE SITES

SOP: 4-5

Revision: 5

Date: December 11, 2002

Page 6 of 9

3. Rinse the item in potable water. Rinse water should be replaced as needed, generally when cloudy.
4. Using a hand sprayer, wash bottles, or manual-pump sprayer, rinse the item with de-ionized water (ASTM Type II or better).
5. If sampling for metal analytes, rinse the item with 10% nitric acid (for stainless steel, glass, plastic, and Teflon), or 1% nitric acid (for items made of low-carbon steel) followed by a de-ionized water (ASTM Type II or better) rinse.

NOTE: Care should be taken not to get nitric acid on skin or clothing. This step should not be used unless required by sampling needs as dictated in the field plan.

CAUTION: Do not allow nitric acid to contact methanol or hexane. Contain nitric acid waste separate from organic solvents.

6. If sampling for organic analytes, rinse the item with methanol or approved organic solvent.
7. If required by the field plan, when sampling for polar organic compounds such as pesticides, polychlorinated biphenyls (PCBs), and fuels, rinse the item with hexane or approved alternatives, followed by a second methanol rinse.
8. Thoroughly rinse the item with de-ionized water (ASTM Type II or better).
9. Allow the item to air dry completely.
10. After drying, reassemble parts as required and wrap the item in clean plastic wrap or in aluminum foil, shiny side out.
11. Record equipment type, date, time, and method of decontamination in the appropriate logbook.
12. After decontamination activities are completed, collect all contaminated waters, used solvents and acids, plastic sheeting, and disposable gloves, boots, and clothing. Place contaminated items in properly labeled drums for disposal. Liquids and solids must be drummed separately. (Refer to site-specific plans for labeling and waste management requirements).

5.4 Pump Decontamination

Follow the manufacturer's recommendation for specified pump decontamination procedures. At a minimum follow these steps when decontaminating pumps:

FIELD EQUIPMENT DECONTAMINATION AT NONRADIOACTIVE SITES

SOP: 4-5

Revision: 5

Date: December 11, 2002

Page 7 of 9

1. Set up the decontamination area and separate "clean" storage area using plastic sheeting to cover the ground, tables, and other surfaces. Set up three 55-gallon drums and one or more containers of ASTM Type II water (or as specified in the field plan). One drum shall contain dilute (non-foaming) soapy water, the second drum shall contain potable water, and the third drum shall be empty to receive waste water.
2. The pump should be set up in the same configuration as for sampling. Submerge the pump intake (or the pump, if submersible) and all downhole-wetted parts (tubing, piping, foot valve) in the soapy water of the first drum. Place the discharge outlet in the wastewater drum above the level of the wastewater. Pump soapy water through the pump assembly until it discharges to the waste drum. Scrub the outside of the pump and other wetted parts with a metal brush.
3. Move the pump assembly to the potable water drum while leaving discharge outlet in the waste drum. All downhole-wetted parts must be immersed in the potable water rinse. Pump potable water through the pump assembly until it runs clear.
4. Move the pump intake to the ASTM Type II water can. Pump the ASTM Type II water through the pump assembly. Pump the volume of water through the pump specified in the field plan. Usually, three pump-and-line-assembly volumes will be required.
5. Decontaminate the discharge outlet by hand following the steps outlined in Section 5.3.
6. Remove the decontaminated pump assembly to the "clean" area and allow it to air dry upwind of the decontamination area. Intake and outlet orifices should be covered with aluminum foil to prevent the entry of airborne contaminants and particles.
7. Record the equipment type, serial number, date, time, and method of decontamination in the appropriate logbook.

5.5 Instrument Probe Decontamination

Instrument probes used for field measurements such as pH meters, conductivity meters, etc. will be decontaminated between samples and after use with ASTM Type II, or better, water.

5.6 Waste Disposal

Refer to site-specific plans for waste disposal requirements. The following are guidelines for disposing of wastes:

FIELD EQUIPMENT DECONTAMINATION AT NONRADIOACTIVE SITES

SOP: 4-5

Revision: 5

Date: December 11, 2002

Page 8 of 9

1. All wash water, rinse water, and decontamination solutions that have come in contact with contaminated equipment are to be handled, packaged, labeled, marked, stored, and disposed of as investigation-derived waste.
2. Small quantities of decontamination solutions may be allowed to evaporate to dryness.
3. If large quantities of used decontamination solutions will be generated, each type of waste should be separated in separate containers. This may permit the disposal of wash water and rinse water onsite or in a sanitary sewage treatment plant rather than as a hazardous waste. If an industrial wastewater treatment plant is available onsite, the disposal of acid solutions and solvent-water solutions may be permitted.
4. Unless otherwise required, plastic sheeting and disposable protective clothing may be treated as solid, non-hazardous waste.
5. Waste liquids should be sampled, analyzed for contaminants of concern in accordance with disposal regulations, and disposed of accordingly.

6.0 RESTRICTIONS/LIMITATIONS

Nitric acid and polar solvent rinses are necessary only when sampling for metals or organics respectively. These steps should not be used, unless required, because of the potential for acid burns and ignitability hazards.

If the field equipment is not thoroughly rinsed and allowed to completely air dry before use, volatile organic residue, which interferes with the analysis, may be detected in the samples. The occurrence of residual organic solvents is often dependent on the time of year sampling is conducted. In the summer, volatilization is rapid, and in the winter, volatilization is slow. Check with your EPA region, state, and client for approved decontamination solvents.

7.0 REFERENCES

Department of Energy, Hazardous Waste Remedial Actions Program, *Standard Operating Procedures For Site Characterization*, DOE/HWP-100/R1, September 1996.

Department of Energy, Hazardous Waste Remedial Actions Program, *Quality Control Requirements For Field Methods*, DOE/HWP-69/R2, September 1996.

American Society for Testing and Materials, *Standard Practice for Decontamination of Field Equipment at Nonradioactive Waste Sites*, ASTM D5088-90, June 29, 1990.

**FIELD EQUIPMENT DECONTAMINATION
AT NONRADIOACTIVE SITES**

SOP: 4-5

Revision: 5

Date: December 11, 2002

Page 9 of 9

U.S. Environmental Protection Agency, Region II, "*CERCLA*" *Quality Assurance Manual*, Revision 1, 1989.

U.S. Environmental Protection Agency, Region IV, *Engineering Support Branch Standard Operating Procedures and Quality Assurance Manual*, 1986.

U.S. Environmental Protection Agency, *A Compendium of Superfund Field Operations Methods*, EPA/540/P-87/001.1, 1987.

TARGET SHEET
EPA REGION VIII
SUPERFUND DOCUMENT MANAGEMENT SYSTEM

DOCUMENT NUMBER: 2009648

SITE NAME: LIBBY ASBESTOS

DOCUMENT DATE: 04/01/2003

DOCUMENT NOT SCANNED

Due to one of the following reasons:

- ☐ PHOTOGRAPHS
- ☐ 3-DIMENSIONAL
- ☐ OVERSIZED
- ☐ AUDIO/VISUAL
- ☐ PERMANENTLY BOUND DOCUMENTS
- ☐ POOR LEGIBILITY
- ☐ OTHER
- ☐ NOT AVAILABLE
- ☒ TYPES OF DOCUMENTS NOT TO BE SCANNED
(Data Packages, Data Validation, Sampling Data, CBI, Chain of Custody)

DOCUMENT DESCRIPTION:

APPENDIX G Baseline Groundwater Data for Monitoring Wells
CDM-MW-7 and CDM-MW-8